TOPICS OF THE MONTH

Delivery dates and costs—two fields for co-operation

THE healthy development of chemical engineering in Britain depends to a considerable extent on co-operation between the two main industrial groups it mostly concerns—the chemical and process industries on the one hand and the chemical plant manufacturers on the other. The fact that chemical engineering forms a strong link between these two groups is a major reason why there have been plenty of examples of co-operation on technical and academical matters; the recent decision of the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association to join in the sponsorship of certain chemical engineering research projects in the universities is excellent proof of these industries' awareness of their mutual needs.

However, when it comes to the commercial and practical aspects of chemical plant design and manufacture, it is evident that co-operation between the two sides falls short of the ideal. A case in point is chemical plant prices. To anyone who attended the recent London symposium on chemical engineering economics, reported on in this issue, it was evident that, while chemical manufacturers and plant suppliers are capable of helping each other with the broader problems of costing, there is altogether too much time wasted when it comes to assessing the actual order of cost for a chemical project. The situation could be much improved if reliable cost data could be made regularly available; this would make possible more accurate pre-design estimates for chemical plant while plant manufacturers would be saved the trouble of preparing numerous quotations which are only needed for estimating purposes. Chemical companies could help themselves, too, by doing away with the unnecessary secrecy that surrounds some of their cost estimating statistics; much of the data from the records of past projects could be shared with other companies, or published for the benefit of all, without fear of revealing vital secrets. CHEMICAL & PROCESS ENGINEERING, which publishes indices of chemical plant costs regularly each month, and from time to time includes articles and commentaries on cost estimating, is always glad to consider contributions of this sort.

A subject that seems to be even more a thorn in the side of the chemical and chemical plant industries at present is that of delivery dates, and at the annual dinner of the British Chemical Plant Manufacturers' Association, held in London recently, some 700 members and guests heard the views of both Mr. H. W. Fender, chairman of the Association, and Sir Miles Thomas, chairman of Monsanto Chemicals Ltd. Mr. Fender pointed out that, ever since the war, an attitude of mind has developed throughout British industry which has led to delivery dates not being treated as sacred; there were always plenty of other people to blame. As a result the customer, to protect himself, developed a habit of asking for earlier deliveries than he needed. Mr. Fender urged that the customer asks for the delivery he really needs, while the supplier should offer only what he knows he can maintain. Nor should the plant manufacturer be given a difficult delivery date because of a delay in finalising designs. Suppliers and users of chemical plant, Mr. Fender said, should solve these problems on a basis of mutual trust.

In his speech as chief guest, Sir Miles Thomas, who was well known as chairman of British Overseas Airways Corporation until taking over the chairmanship of Monsanto Chemicals in 1956, pointed to the *Comet IV* aircraft as an instance of on-time delivery and said that just as B.O.A.C. had to have this aircraft on schedule and to specification if the maximum advantage was to be obtained from it, so it is with the chemical manufacturer who has ordered new plant. All his production estimates, his market assessments and his price calculations are based on the assumption that equipment ordered will be delivered on agreed dates and that it will work at planned efficiency with the minimum delay. Delivery dates should be sacrosanct and the time of delivery should be regarded as an intrinsic element of quality and of workmanship. He said that delivery of plant has improved considerably over the last year and it was to be hoped that this improvement was not due solely to a falling off in the demand for raw materials or to a lesser degree of pressure on fabricators.

Chemical engineering in Israel

IN the underdeveloped countries the acquisition of engineering skills, as well as being helped along by technical aid and the setting up of training establishments, is perhaps given an even more positive emphasis through the activities of big companies which set up manufacturing operations there. In Israel, for instance, there is the big Haifa firm of Fertilisers & Chemicals Ltd., which, as one example of its progress, was recently able to announce that it had sold a French company the engineering knowhow for a dicalcium phosphate plant to be set up in Belgium. Part of the equipment for the project will be made in Israel.

The same company's engineering staff have recently been engaged on the construction of a spherical container of over 12 m. diameter to hold 1,000 cu.m. of liquid ammonia. This steel globe weighs 84 tons without its supporting structure and is made of 24 steel plates, 18.5 mm. thick. The steel sphere will be insulated by a 150-mm. layer of cork against contraction and expansion resulting from the difference in day and night temperatures.

More and more synthetic rubber

THE new British synthetic rubber plant which we describe in an article this month and the £15-million plant recently brought into production in Western Germany illustrate the determination of European countries to follow the American lead in setting up rubber plants to utilise some of the products of oil refineries. Other countries following the new trend include Italy, the Netherlands and France, and it is estimated that by 1960 Western Europe will be producing some 300,000 tons of synthetic rubber.

With other installations in Canada, the U.S.A. and the Far East, it is expected, according to the Petroleum Information Bureau in London, that free world capacity for producing synthetic rubber should approach $2\frac{1}{2}$ million tons p.a. by the end of the present decade. This estimate falls into perspective if it is recalled that, last year, world usage of rubber was 1.9 million tons of the natural product and a further 1.2 million tons of synthetic.

Air dilution in sulphuric acid plant

AIR dilution has been used successfully for nine years to improve conversion at a contact sulphuric plant at Oldbury, Lancs., and provides an example which may well be of use to other plants faced with similar problems. An I.C.I. hot-gas brimstone-burning plant erected in pre-war days, it has been able to meet air pollution requirements and achieve a margin of safety, approaching very closely to the requirements for a post-war four-stage plant whilst being still, basically, a two-stage unit with only relatively inexpensive modifications.

This two-converter unit at the end of the war found itself working at its rated capacity of 50 tons of monohydrate a day, but during the next four years demand increased until the blower was flat out and the only way to get greater output was to increase the gas strength. This was done gradually until the plant was working on a substantial overload. Conversion fell and the acidity of the exhaust rose until it attracted pointed comment from the Alkali Works Inspector. The economic limit was at hand, too. If the extra sulphur loss over the whole of the output is debited against the relatively small increase in acid made, the limit is reached sooner than a casual examination of the cost sheets suggests. Something had to be done.

So Mr. W. N. Hackett and Dr. R. W. Riding explained at a meeting of the Fertiliser Society on October 30, and they went on to describe the various expedients that were examined. Addition of a third converter proved impracticable and so they turned to interstage dilution, deciding eventually to divert cold, dry air from the drying towers to the dilution point and to let the initial SO_2 concentration ride up to 8 to 10% with a consequent increase in burner temperature.

Addition of cold air between the two layers of catalyst in the first converter improved the conversion efficiency at constant load and the improved first mass conversion was followed by an improvement in overall plant conversion. Introduction of cold dilution air between the layers of the second converter gave only a marginal improvement in overall conversion when the first mass conversion was 80% or more. With 77 to 80% the improvement was measurable at 0.1 to 0.2%; with a lower first conversion the advantage could be expected to be greater.

While air dilution may not be the best solution for all such plants and some will already be able to achieve a margin of safety, there may be some cases similar to this where air dilution may provide just that extra little bit of conversion efficiency necessary to get the plant out of difficulty and remove the strain of working without a safety margin.

Instruments of progress

REMARKABLE though the contributions of instruments and measuring devices have been to the general progress of technology, there are still some vital problems to be tackled if further progress is not to be held up. Thus, as operating instrumentation systems develop more and more into an intricate maze of interdependent components the problem of estimating systems' life-expectancy and reliability becomes extremely difficult. This is a special problem, for the performance of any one component becomes in a sense a function of almost every other component. Without the development of a rational basis for evaluating this intendependency, the whole future of instrumentation may be restricted.

Attention is drawn to this problem by Mr. A. V. Astin, director of America's National Bureau of Standards, who at a recent meeting of the American Society for Testing Materials* cited some areas of critical scientific need for which instrumentation is still inadequate. High-pressure research, for instance, is a field which presents exciting possibilities for producing new forms of matter, but the obstacles to efficient progress are those of physical standards, techniques of measurement, and instrumentation. These are urgently needed at the research stage in advance of the development of engineering data on the properties of materials at these new pressures. Despite improvements in pressure-measuring and pressure-producing devices there is a need for further attention to both mechanical and electrical features of high-pressure instrumentation.

High temperature is another field for which research scientists are lacking in standards, instruments, measurement techniques and materials data which better instruments would make possible. Advances in high-speed flight, high-energy propulsion systems, ballistic missiles, atomic reactors and power plants, and a major industrial shift to high-temperature production, have brought overwhelming requirements for new basic data, new heat-resistant materials and new types of instruments and measurement techniques which can operate at temperatures well above 1,000° C. According to Mr. Astin, the lack of measurement techniques and devices is proving to be one of the severest deterrents to laboratory and field experiments.

*A.S.T.M. Bulletin, 1958 (232), 7-11.

Computer aids plant design

IT is now possible to solve start-up and operating problems of a chemical plant before the plant is built by means of an analogue computer. The efficacy of this new aid for the chemical engineer (the second of our series of articles on analogue computers appears in this issue) was demonstrated on the £2½ million hydrogen peroxide plant which Laporte Chemicals Ltd. have just started up at their Baronet Works, Warrington. The plant and process are completely new. Hydrogen peroxide is made by a cyclic process involving the autoxidation of 2-ethyl anthraquinol yielding 2-ethyl anthraquinone and H_2O_2. The anthraquinone is then catalytically hydrogenated to the anthraquinol which is fed back into the process and recycled. The process is both more productive and more economical than the electrolytic process of hydrogen peroxide manufacture and will substantially increase Laporte's output, enabling them to meet the large military demands for H_2O_2 for use as an oxidant in rocket fuels and also the growing industrial demands for such uses as the manufacture of oxygenated compounds for detergent manufacture.

The plant is controlled from a central control panel which is some 22 ft. long, the plant itself including surge tanks, reaction vessels and a 24-plate extraction column (for separating hydrogen peroxide from the solution of 2-ethyl anthraquinone) in a closed system with seven subsidiary loops. The major vessels are probably the largest which have ever been fabricated in aluminium and include some up to 80 ft. high and 12 ft. in diameter. We shall be publishing more details of the plant and process in our next issue.

The analogue computer project was a joint venture between Laporte's engineers and the computer experts of E.M.I. Electronics. The information required from the computer study included: (1) confirmation that the capacities of the various vessels would be sufficient for all expected major flow changes (including start-up and shut-down conditions); (2) the determination of optimum control settings of the automatic controllers; (3) confirmation that no interaction, which might cause sustained hunting, would occur between various vessels and controllers in the plant; (4) determination of any points of particular sensitivity to oscillatory disturbances.

Models for flow studies

SUCCESSFUL use of two- and three-dimensional models has been made by the British Coal Utilisation Research Association for studying flow processes in combustion or gasification equipment. To obtain a two-dimensional picture of the gas flow pattern through, say, a boiler, a sectional drawing is covered with a plate of *Perspex* and the essential flow channels are picked out in *Perspex* strip, placed on edge and cemented to the base plate with a solution of *Perspex* in chloroform. Parts of the equipment through which there is no flow are blacked out with paint. The model is placed on a glass table evenly illuminated from beneath. Water is introduced into the model where, on the full-scale, the gases or air would enter the plant and is removed where the gases would normally leave. The flow of the water is controlled by its rate of supply, and the level in the model by an adjustable weir placed at the outlet. The flow pattern is traced out by sprinkling a powder—*e.g. Bakelite*, 70 mesh—on the water surface.

With a two-dimensional model of this kind it is a simple matter to try the effect of baffles, different modes of air admission and other modifications intended to secure the desired results. The method of trial and error can be extremely quick in giving a practical solution to a flow problem.

In some instances the flow of gases in an appliance cannot be considered as being even approximately two-dimensional, and in these cases a more elaborate technique has to be employed. A three-dimensional transparent model is used, and a section of the model is illuminated to show the movement of tracers. Again, water is used as the fluid medium, and the model is mounted in a tank and completely submerged in water. This reduces the distortion due to reflection from the curved surfaces, and avoids condensation troubles. A rig employed in the B.C.U.R.A. has been used successfully as an aid to the development of the small slagging cyclone combustor at Leatherhead.

Reactor for kinetic studies

AN experimental reactor which uses a recirculation technique has been used in the United States for studying the kinetics of a typical rapid reaction, the catalytic hydrogenation of propylene. It is claimed that a recirculation differential reactor eliminates many of the experimental difficulties of determining rate data for highly exothermic or endothermic reactions occurring at rapid rates. By proper design of the reactor, temperature gradients in the catalyst section can be maintained within acceptable limits. High gas velocities in the reactor prevent interfering mass-transfer effects. Owing to the small conversion per pass, gas compositions within the reactor are more uniform than those encountered in ordinary differential reactors. Not all reactions, however, may lend themselves to treatment in this type of equipment, as admixture of products to the feed may promote secondary reactions.

The reactor, discussed by T. K. Perkins and H. F. Rase in *A.I.Ch.E. Journal*, 1958, **4** (3), 351-355, consists of four separate tubes which can be used either individually or in parallel. In the experiments described, catalyst pellets were placed in one of the tubes, the other three being blocked with stainless-steel plugs. The tubes were attached to a floating head at the bottom to prevent excessive strain at high temperature during reduction of the catalyst, and the outside of the water jacket was wrapped with electrical resistance wire for heating the reactor during the reduction period. The complete reactor was surrounded with 2-in.-thick magnesia insulation. The equipment also included a specially constructed four-cylinder diaphragm pump for gas recirculation.

Chemical engineering laboratories

HOW should laboratories for the teaching of chemical engineering be equipped ? It is nearly ten years since the Institution of Chemical Engineers published a pamphlet on this subject and the appearance of a new one* is to be welcomed, embracing as it does the considerable experience that has been gained during a period in which the number of full-time chemical engineering courses in Britain has more than doubled.

It is recommended that three types of laboratories should be provided: a chemical laboratory, a physical laboratory and a 'plant' laboratory housing the engineering equipment. Storage and workshop facilities and accommodation for demonstrators, for writing up laboratory notes and for storing drawings are also needed. The pamphlet lays down suitable dimensions for these laboratories and notes that typical good accommodation figures for teaching chemical engineering to first-degree level vary from 100 to 150 sq. ft. per student with a minimum of 3,000 sq. ft.

A suggested list of equipment for permanent assembly in the chemical laboratory is given, this equipment being required both for teaching in the earlier stages of a chemical engineering course and for evaluating the performance of some items of equipment in the plant laboratory. Turning to the physical laboratory, it is explained that the function of this laboratory is to give the student experience of various methods of measuring variables associated with industrial process work, and to provide means of calibrating process plant instruments.

The plant laboratory provides a home for equipment designed to demonstrate the principles of mass and energy transfer and to illustrate the more common unit operations. A major part of the pamphlet is devoted to equipment for this laboratory including units for studying the flow of liquids, gases and heat; evaporation; distillation; solvent extraction; drying of solids; gas absorption; filtration; classification and concentration of solids; and solids handling including size reduction, mixing and conveying.

To use all this equipment and apparatus to the best advantage it is necessary to maintain a reasonable workshop and laboratory staff. For the small department a reasonable allocation would be one workshop technician and one laboratory steward, while larger departments will of course require several such staff together with a storekeeper and laboratory assistants.

*'Notes on Laboratories for the Teaching of Chemical Engineering,' Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

Seasonal Greetings

TO ALL OUR READERS

Evaporation pioneers

WITH two articles on evaporation appearing in this issue, it seems appropriate to recall some of the pioneering efforts of the Kestner Evaporator & Engineering Co. Ltd. in this field, conveniently recorded in the company's handsomely produced, illustrated book commemorating the Kestner golden jubilee. In a foreword, Mr. J. Arthur Reavell, founder and chairman, explains the beginnings of the company and his early association with Paul Kestner, the French inventor of the climbing-film evaporator. It was a most difficult task to put over the idea of the long, vertical, tubular evaporator to industries wedded to the vacuum pan-type unit with either steam coils or short bundles of tubes only a few feet long. Prejudice had been fostered by unsuccessful attempts to launch long-tube horizontal evaporators with the liquor inside the tubes and steam outside, or *vice versa*. To the argument that the fault lay in the lengthy tube, Mr. Reavell countered to the effect that it was impossible to give equal feed to a number of horizontal tubes and equal liquid distribution over the surfaces. He not only proved this point with his first plant but also proved another prophecy: that the velocity of the climbing film inside the tube would be so high that the consequent time of contact with the heated surface of the tube would permit the most delicate of liquors, such as fruit juices, to be evaporated without loss of vitamin.

The company speedily learnt to elaborate on the original invention, and the climbing film was followed by the falling film, the perfection of vacuum and pressure techniques, and horizontal evaporators. Not that the company's activities were confined solely to evaporators, even in those early days, for it soon developed a satisfactory sale of acid elevators and fans for acid gases, and also supplied complete plants for glue, gelatine and tan extracts. Another interesting point recalled by Mr. Reavell is that, among the handicaps of the early years, not the least was the restricted nature of the available materials of construction: they amounted to cast and wrought iron, mild steel, lead, copper, tin and wood. Few of the metals could be supplied to analyses such as are demanded today. There was no aluminium, stainless steel, the alloys that are known and used today, or inert resins. The techniques of welding were scarcely in their infancy.

The Kestner book, before going on to discuss the company's activities in numerous other fields such as drying, acid-resisting materials, high-temperature process heating, etc., includes a short chapter on evaporation which not only traces the technical development of Kestner's original design and the way it has been adapted to solve industrial chemical and other problems, but also touches on such nostalgic topics as *Golden Syrup*, produced with the aid of Kestner evaporators, filled into the familiar green-and-gold tins and spread by loving mothers and nannies upon nursery bread and butter. The history of this well-known chemical engineering company is indeed a colourful one.

SUBMERGED EVAPORATION

and its application to fish stickwater recovery

By G. A. Carpenter, B.Sc., Dip.Chem.Eng., A.M.I.Chem.E.
(Association of Fish Meal Manufacturers)

This article briefly reviews the scope and historical development of submerged evaporation and discusses its application to the recovery of fish stickwater. Details of experiments connected with this novel application are given.

ALTHOUGH submerged evaporation is a process that is frequently omitted from chemical engineering textbooks, it has, nevertheless, become an established industrial method for evaporating liquids.[1–11] In terms of classical chemical engineering, it can be called a unit process.

It is desirable to define submerged evaporation and, to do this, it is necessary to review what may be called 'direct' evaporators. By analogy with a well-established convention in the classification of driers,[12] a 'direct' evaporator is one which utilises hot gases in direct contact with liquid, and an 'indirect' evaporator one which accomplishes evaporation by transferring heat through a separating wall. Radiant evaporation is a third type which is not considered here.

Direct evaporators can be divided into four main types:

(*a*) The Porrion evaporator, used exclusively in the paper industry. Rotating discs dip into the liquid and hot gases pass over the film of liquid formed on the discs.

(*b*) The Gaillard tower, used for concentrating sulphuric acid.[13] Hot gases pass up a tower and meet descending liquid in a similar manner to a gas absorption tower.

(*c*) Evaporators in which hot gases are blown into the liquid being evaporated.

(*d*) Evaporators in which hot gases are generated by means of submerged combustion beneath the surface of the liquid being evaporated.

Only cases (*c*) and (*d*) are submerged evaporation, and only case (*d*) involves submerged combustion.

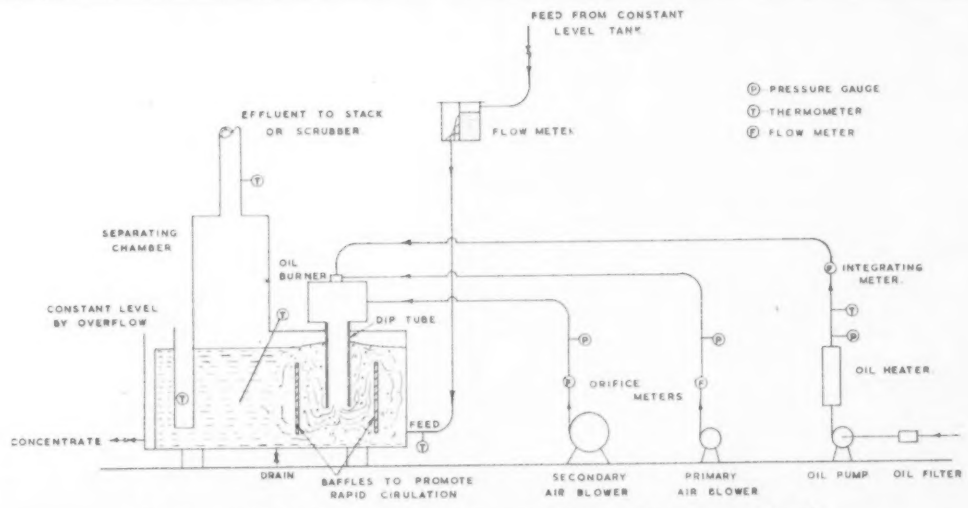
Historical development

The first example of the industrial use of submerged evaporation is the Kessler acid concentrator in 1891[14] in which hot gas was blown into dilute sulphuric acid. The drum acid concentrator was similar.[13]

Experiments involving submerged combustion were started by Collier four years ealier[15] and development continued until 1901[16–18] when Smethurst first applied the process to chemicals as distinct from pure water. Further developments[19–22] arrived at the first really satisfactory submerged burner designed by Brunler in 1923.[23]

Details of this early work are dealt with very adequately elsewhere.[24–30]

Brunler was more concerned in 1923 with using his submerged burner for generating steam than for evaporating chemicals, and his submerged-combustion boiler is described in detail.[23, 26, 29, 30] This boiler, however, appears never to have been used commercially, presumably because the steam produced was mixed with air and combustion products and there-



Arrangement of submerged evaporator used for experiments on stickwater.

fore of limited use. It was, indeed, advocated that the steam-gas mixture could be used in a non-condensing engine,[31–33] but the low efficiencies of those engines would be a serious drawback.[30, 34] Steam heavily polluted with air is certainly of little use for process work. In spite of this serious disadvantage, the submerged-combustion boiler possessed a very high thermal efficiency, and the savings in weight and bulk compared with a conventional boiler, due to the absence of tubes for heat transfer, were enormous.

About 1925, a highly refined burner was invented by Hammond[24,25,30,34–38] to ensure complete, safe and accurately controlled combustion. In order to avoid contact between the hot gases and liquid being evaporated, a special modification in the form of a circulating metal bath was also developed. This made possible the generation of pure steam and concentration of caustic soda,[33] but was not developed commercially.

Between 1923 and 1930, much speculation existed as to the possibilities of submerged evaporation. Claims were made that the process could be used for the concentration of phosphoric and hydrochloric acids, and ammonium chloride,[35] of zinc chloride, sulphate pulp and sewage sludge,[26] for ore reduction and oil cracking,[32] and heating of dye vats.[37] Several of these claims were eventually justified commercially.

By 1931, Hammond's burner was applied to the concentration of phosphoric acid[39] and this application is now an established process.[5, 7] The evaporation of sulphite pulp (which has a serious frothing tendency) in the paper industry on a pilot scale is described in great detail.[40, 41] Also at about the same time the Elmore process for evaporating a mixture of brine and hydrochloric acid was developed in Britain by Swindin using Smith's burner.[7]

In 1935, the American Ozark process was developed for the dehydration of sodium sulphate[1] and the Ozark burner was later applied to citrus waste.[5, 6]

More recently in America, submerged evaporation has been used for magnesium chloride,[3] aluminium sulphate,[4] potassium chloride and calcium chloride,[5] for recarbonating city water,[5] evaporating sea-water to give sea salt[9] and several other processes.[10]

In Britain, the development of submerged evaporation in the chemical industry was due largely to Swindin. It has found its main use for the recovery of spent pickle liquors in the steel and associated industries.[2, 7, 11, 42] Other uses mentioned are for zinc chloride,[7] phosphoric acid, trisodium phosphate and sodium tungstate.[11]

Technical aspects of submerged evaporation

The following are the main principles that had to be discovered by the pioneers of submerged evaporation and combustion.[25, 30]

(1) Accurate metering of air and fuel (usually gas) in the correct ratio.
(2) Adequate mixing of the air and fuel.
(3) Maintenance of fuel and air velocities greater than that of flame propagation to prevent blow-back.
(4) Maintenance of a hot refractory in the burner to keep the latter alight and ensure complete combustion.
(5) Invention of an easy method of lighting the burner.
(6) Use of an air lift around the burner to cool the latter and maintain circulation.
(7) Discovery of suitable infusible refractories for the burner lining.

It is probable that nearly all the applications hitherto described use gaseous fuel of some kind. Reference is made to the possible use of pulverised coal,[29] but no account can be found of its actual use. The present tendency in Britain is to use heavy oil in place of gas, due either to the unavailability or high price of gas. Oil fuel necessitates a larger type of burner (for the same heat release) in order to ensure complete combustion,[7] although recent developments have produced burners of very high combustion intensity.[43] A small furnace is situated above the point where the hot gases enter the liquid, so that actual combustion of the oil takes place in the furnace above the liquid, and hot gases only enter the liquid. Under these circumstances, combustion is not actually submerged and the process can only be termed submerged evaporation.

Because air or gases have to be blown into the liquid, a reasonably powerful compressor or blower is necessary. With gaseous fuels, it is safest to compress the fuel and air separately before mixing. With fuel oil, air only is involved in the compression. In calculating overall evaporation efficiencies, account must be taken of the energy involved in compressing the gas or air.

A very interesting development is the use of a 'pre-evaporator' described by Swindin.[7] The effluent gases and vapour from the evaporator are passed through a special heat exchanger at a velocity of 200 ft./sec. The cold feed liquor is also passed through the heat exchanger along with a current of cold air, resulting in considerable evaporation at a low temperature. It is claimed that the high velocity of the air and vapours enables an O.H.T.C. of 150 B.Th.U./sq.ft./hr./°F. to be obtained.

It should be noted that it is inevitable that all submerged evaporators use a high heat potential for an operation that normally requires a low one.

Advantages and disadvantages

To appreciate the special fields in which submerged evaporation has found a place, it is desirable to summarise its advantages and disadvantages relative to conventional steam-heated evaporators. Its advantages are as follows.

(1) Most important is that no wall-heating surface is involved. All heat is transferred directly from hot gases to the liquid. This implies several things:

(*a*) Heating surfaces of heat-conducting metal do not exist, and the entire evaporator can be made corrosion-resistant by means of rubber, glass or enamel lining or by stoneware construction, the insulating properties of these latter materials being of no consequence.
(*b*) The use of large quantities of corrosion-resistant metal is avoided and capital cost is low.
(*c*) No heating surface exists upon which scale can build up, and the process is therefore suited for scale-forming substances, *e.g.* those whose solubility decreases with rising temperature.

(2) No steam boiler is required. This implies smaller capital cost and a saving in fuel efficiency.

(3) Liquids which froth or foam (usually colloids) can be evaporated with less difficulty.

(4) The temperature of evaporation is reduced to about 186°F.

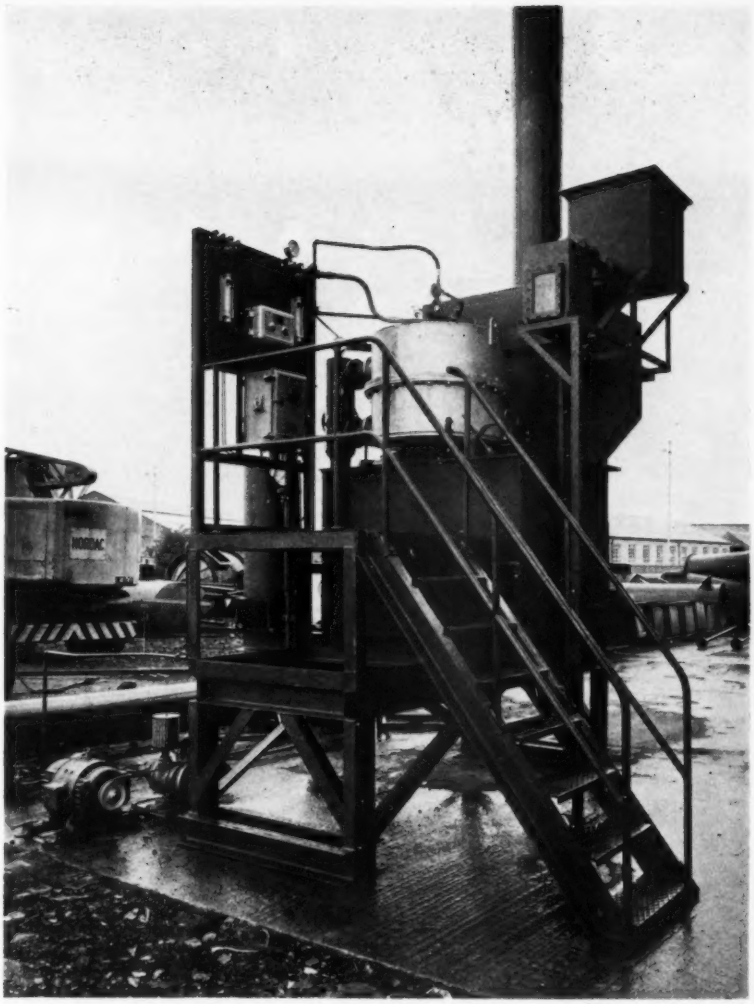
(5) Viscous liquids can be evaporated without difficulty due to the absence of heating tubes and the intense agitation produced by the hot gases.

The disadvantages of submerged evaporation are as follows:

(1) Coal cannot be used as fuel.

(2) The steam multiple-effect principle can be used only to a limited extent and then to provide only 'double-effect' evaporation.[7]

(3) Contamination of the liquid being evaporated by combustion gases



[*Courtesy: Nordac Ltd.*

Submerged evaporator identical to that used for tests described.

precludes its use for some very pure substances or substances such as caustic soda which would react with carbon dioxide, apart from the novel process using hydrogen as fuel.[10]

Application to fish stickwater recovery

This is a recent development and probably the only example of the use of submerged evaporation for evaporating a liquid of organic origin. In the reduction of oily fish for fish meal and oil,[44–46] an aqueous liquor termed stickwater is obtained containing 7 to 10% total solids, mostly soluble protein.

Originally, stickwater was a waste product, but was recovered by evaporation as early as 1939 in America[47] to give 'fish solubles.' In recent years, the industries in Norway, Britain and South Africa have widely adopted recovery of stickwater using multiple-effect evaporators and disposing of the solubles by mixing with press-cake and drying the mixture to give what is termed 'whole meal.' Generally, the value of the solids recovered is greater than the cost of recovery even for the short and erratic seasons encountered in the industry. Nevertheless, the total of working hours per year can be so small that the first cost of the evaporator may become as important as economy of operation. Scale formation presents a serious problem in steam evaporators operating on stickwater. A submerged evaporator with its low first cost thus has two distinct advantages. Two possible disadvantages which have yet to be assessed are the production of some nuisance odours and some darkening of the product.

Experimental

A trial was run on a submerged evaporator operating on stickwater. The plant was fitted with a Swindin burner with a heat release of 4 million B.Th.U./hr. (combustion intensity, 1 million B.Th.U./hr./cu.ft.) and an evaporation capacity of 2 tons/hr. of water. Fuel used was 200 sec. residue oil.

Steady conditions were maintained for 12 hr., and the following quantities measured every half-hour:

(1) Flow rates:

(*a*) Stickwater feed by an orifice box (previously calibrated). Due to a high content of suspended solids in the stickwater, the extreme simplicity of this flow meter was an advantage.

(*b*) Solubles produced by running into a weighed container for 12 min.

(*c*) Air flow rates (primary and secondary air to burner) by orifice plates and water gauges.

(*d*) Fuel consumption by an integrating oil meter.

(2) Temperatures of feed, product, oil, liquor and effluent vapours.

(3) Pressures of oil line, primary and secondary air, and effluent vapour.

(4) Current taken by the secondary air blower.

(5) Analyses.

The stickwater solids content was measured by evaporation on a water bath followed by oven drying, and the solubles water content was measured by the toluene method of Dean and Stark.

The evaporator was initially filled with stickwater and, after starting up, the level of liquid in the evaporator was kept constant by addition of feed. As evaporation proceeded and the liquid in the evaporator became more concentrated, an increasing feed rate became necessary. After a period of about 5 hr. the desired concentration was reached and the feed rate was adjusted and kept at the value necessary to maintain this desired concentration. The heat release of the burner being constant under normal circumstances, the degree of concentration is determined entirely by the feed rate and the feed composition.

Results

The results were as shown in Table 1 on the following page, where calculations are also shown.

Discussion

In the materials balance, the weights of solids agree to $2\frac{1}{2}\%$, which is reasonable.

In the heat balance, 336,000 B.Th.U. are not accounted for except as heat losses or heat of concentration. Although the latter would be expected to be low for a solution of fish protein (of the order of 50,000 B.Th.U./hr.), the former would be expected to be high (of the order of 200,000 B.Th.U./hr.) in view of the facts that the plant was not lagged and that a high wind swept through the building during the trial.

A discrepancy of 100,000 B.Th.U. is an error of 2.2%, and its main source is probably the evaporation figure, the weight of which is obtained by difference in the materials balance.

Apart from a technical fault in the oil heater, the evaporation process operated satisfactorily. The stickwater was not pretreated in any way, as a result of which the content of suspended solids in the product was very high.

Previous experience had shown that at a concentration of about 55% solids in the product, scorching occurs in the evaporator and is indicated by a sudden rise in the effluent vapour temperature and a dark-grey product. During the trial described here, however, with a solids content in the product of only 40%, no tendency to scorch occurred, the effluent vapour temperature was exceedingly constant at about 2°F. above the liquid temperature, and, clearly, heat was readily transferred from the combustion gases to the liquid, in spite of the considerable viscosity of the liquid. The product here was light to medium grey in colour and completely opaque.

In accordance with Dalton's law of partial pressures, the liquid evaporated at a temperature of 186°F., corresponding to a partial pressure of the water vapour of 8.5 p.s.i. absolute. This reduction in ' boiling point ' may be important as far as quality of product is concerned.

The fuel used being a residue oil, sulphur dioxide is formed during combustion at a rate of 12 lb./hr. This is, however, diluted to about one part in 800 and should not pose a serious corrosion problem. The question of contamination of the solubles by the products of combustion is a matter requiring further chemical and animal nutrition tests. If necessary, a higher-quality sulphur-free oil could be used.

Regarding efficiencies, comparison can be made with steam evaporators working in conjunction with an oil-burning boiler. If the boiler generates 14 lb./steam/lb. oil, and a single-effect evaporator uses 1.2 lb. steam/lb. water evaporated, then, using the latter, water evaporated/lb. oil = 11.6 lb. With a double-effect evaporator using 0.7 lb. steam per lb. water evaporated, water evaporated/lb. oil = 20 lb. The figure of 15.7 lb. for submerged evaporation therefore lies midway between those of single- and double-effect evaporators. This agrees quite well with Austin.[11]

CALCULATIONS

(a) Materials balance (lb./hr.)

IN:	*Solids*	*Water*	*Total*
Feed liquor (7.3% solids)	302	3,838	4,140
Oil	—	—	216
Air primary	—	—	270
Air secondary			5,330
			5,816

OUT:	*Solids*	*Water*	*Total*
Concentrated solubles (39.6% solids)	295	450	745
Evaporated water		3,395	3,395
			4,140
Products of combustion:			
CO_2			681
SO_2			12
N_2 and inerts			2,310
Excess air			2,590
Water vapour			224
			5,817

(b) Heat balance (B.Th.U./hr. on 60°F. datum)

IN:	
Sensible heat of feed liquid	480,000
Sensible heat of oil minus	2,000
Gross calorific value of oil	4,070,000
Power to blowers	56,300
Power to oil heater	7,100
	4,611,400

OUT:	
Sensible heat of product	75,000
Evaporation	3,776,000
Products of combustion:	
CO_2	18,200
SO_2	250
N_2 and inerts	73,350
Excess air	82,200
Water vapour	250,000
Heat losses and heat of concentration (if latter significant)	336,400
	4,611,400

Overall thermal efficiency	92.7%
Evaporation efficiency (excluding power)	92.7%
Evaporation efficiency (including power)	91.2%
Concentration factor	5.56
Water evaporated per lb. oil burned	15.7 lb.

Table I. Results of Trial with Submerged Evaporator Operating on Stickwater

Quantity measured	*Max. reading*	*Min. reading*	*Average of 24 readings*	*Units*
Feed rate (stickwater)			4,140*	Lb./hr.
Production rate (solubles)	870	595	745	Lb./hr.
Primary air flow gauge	5.6	5.4	5.5	In. water
Secondary air flow gauge	4.3	4.1	4.25	In. water
Oil consumption	24.6	22.0	23.3	Gal. hr.
Temperature of feed	185	178	182	°F.
" " product	186	176†	181	°F.
" " oil	165	105	134	°F.
" " liquor in evaporator	187	185	186	°F.
" " effluent vapours	188	186	187	°F.
Oil pressure	51	30	38	P.s.i.g.
Primary air pressure	10.6	10.3	10.4	P.s.i.g.
Secondary air pressure	2.3	2.2	2.3	P.s.i.g.
Chimney suction			0.25	In. water
Current taken by secondary blower	30	30	30	Amp.
Solids content of feed‡	—	—	7.3	%
Solids content of product	43.5	37.2	39.6	%

* Average of several readings only.
† Low readings inaccurate due to cooling, 186°F. taken for heat balance.
‡ All feed samples combined into one, three samples taken from this and average taken.
Fuel data: Bitroleum Shell (200 sec.).
C.V.: 18,900 B.Th.U. lb. or 175,000 B.Th.U. gal.
Density: 0.92 to 0.93.

Conclusions

(1) Submerged evaporation is, as far as technical operation of plant is concerned, a satisfactory means of recovering stickwater.

(2) Further tests are desirable regarding quality of solubles, and air pollution by odours.

(3) The use of a submerged evaporator is particularly advantageous for a short operating season because of its low first cost and reasonable thermal efficiency.

Acknowledgment

The author thanks the Association of Fish Meal Manufacturers for permission to publish this article, and Herring By-Products Ltd. for allowing the use of operating data.

(*For references see page* 433)

A CPE Chemical Engineering Review

EVAPORATION

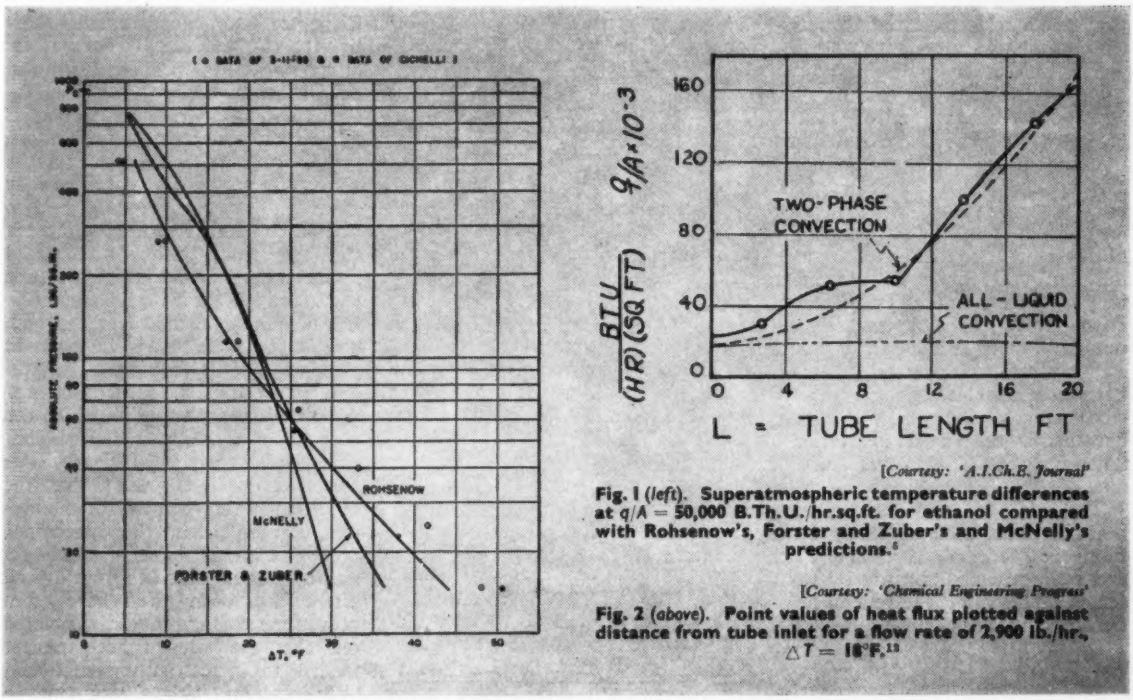
By J. M. Coulson, M.A., Ph.D., D.I.C., M.I.Chem.E.

In this article Prof. Coulson reviews the present methods available for estimating heat transfer to boiling liquids and it is shown that no entirely satisfactory method is at present available. Reference is made to problems of scaling and entrainment in evaporators.

DURING the last two years there has not been a great deal of published work dealing directly with the design or operation of evaporators or the associated auxiliary plant. Nevertheless, work is going on in several fields which should lead to better evaporators. Thus, in the design of a unit it is usually necessary to determine the heat flux that may be obtained under various conditions of operation, the entrainment that may be expected, and the cost of operation both in regard to depreciation and services. The problem of scaling is always present to some extent and the period of operation on stream between descaling operations is often important. In selecting a unit for a given purpose all these considerations will be in mind as well as, perhaps, the advantages of a unit with a low hold-up or one which can be fabricated easily from various types of material.

In all these aspects further research is required both of a fundamental and of a development nature before the design can pass into that small group of chemical plants that can be designed with considerable success from first principles, and not be determined too extensively on the great standby of experience and previous construction. Some of these topics are receiving attention and in this article an indication will be given on the current work on heat transfer to boiling liquids and some remarks on entrainment and scaling are also included.

There has been a considerable increase in the research on boiling liquids



[*Courtesy: 'A.I.Ch.E. Journal'*

Fig. 1 (*left*). **Superatmospheric temperature differences at $q/A = 50{,}000$ B.Th.U./hr.sq.ft. for ethanol compared with Rohsenow's, Forster and Zuber's and McNelly's predictions.**[6]

[*Courtesy: 'Chemical Engineering Progress'*

Fig. 2 (*above*). **Point values of heat flux plotted against distance from tube inlet for a flow rate of 2,900 lb./hr., $\Delta T = 18°F$.**[13]

sparked off by the ideas of using them as possible coolers for nuclear reactors. Perhaps the most noticeable trend in this field is the realisation, surprisingly late, that boiling in tubes is a two-phase flow process and the dynamics of the process are important in determining the heat flux obtained.

Heat flux in boiling liquids

Evaporators are usually arranged for the liquid to boil in tubes which may be short or long and the circulation may be natural or forced. The coil pan and the horizontal tube units must not be forgotten, but in some ways boiling on a submerged surface whilst not perhaps much better understood does not seem to involve quite so many variables. A quick look at recent research papers shows the very considerable gap between the heat flux obtained in such equipment and that obtained in the day-to-day practical operation of existing units. Why is this, and can any improvement be expected?

Heat transfer to boiling liquids

Although the physical relations between the surfaces of bubbles and solids were related by considerations of surface tension and the equilibrium conditions for bubbles could be expressed by physical equations, it was not till 1934 when Nukiyama published his paper on boiling water on a platinum wire that a real start was made in the study of boiling liquids. His simple results showed the existence of the two important regimes of boiling, nucleate and film. In nucleate boiling, active centres give rise to the formation of bubbles and the heat is generally considered to be transferred from the surface to the liquid and then to the bubble. In film boiling the bubbles are formed so fast that they form a film over the surface and the heat must then be transferred through this film either by conduction or at very high temperatures by radiation. Photographic studies, particularly recent ones, taken at 4,000 frames/sec.,[1] certainly indicate that there are quite large areas of solid where no bubbles are arising during nucleate boiling but that at the critical temperature difference there are no free areas of metal.

The first proposals for calculating heat flux under nucleate boiling came from the work of Jakob and Fritz and were extended recently by Rohsenow.[2] They apply the general heat-transfer equation

$$\mathrm{Nu} = Q(\mathrm{Re})^n(\mathrm{Pr})^m$$

by expressing the value for the Reynolds group in terms of the size and velocity of a bubble just leaving the solid. Their final expression can be put in the form,

$$\mathrm{Nu} = \text{const.}\ (\mathrm{Re})^{\frac{1}{3}}(\mathrm{Pr})^{-0.7}$$

or

$$\frac{h_b\beta}{k_L}\left[\frac{\sigma}{g(\rho_L-\rho_v)}\right]^{\frac{1}{2}} = \text{const.}\left[\left(\frac{\beta\, q/A}{\mu_L\,\lambda}\right)\left(\frac{\sigma}{g\,(\rho_L-\rho_v)}\right)^{\frac{1}{2}}\right]^{\frac{1}{3}}\left[\frac{C_L\,\mu_L}{k_L}\right]^{-0.7}$$

This, if rearranged, gives the transfer coefficient in the form:

$$h_b = (C_{sf})\,\frac{(\triangle T)^2 k_L^{5.1} g^{\frac{1}{2}}(\rho_L-\rho_v)^{\frac{1}{2}}}{\beta.\sigma^{\frac{1}{2}}.C_L^{2.1}.\lambda^2.\mu_L^{4.1}}$$

The second approach by Forster and Zuber[3] is based on the growth of a bubble as given by the following form of Kelvin's equation:

$$P_v - P\infty = \frac{2\sigma}{R}$$

Their final expression can be put in the form:

$$\mathrm{Nu} = 0.0015\ (\mathrm{Re})^{0.62}\ (\mathrm{Pr})^{\frac{1}{3}}$$

i.e.

$$h_b = 0.0012\,\frac{(\triangle T)^{0.24}(P_v-P\infty)^{0.75}.k_L^{0.79}.C_L^{0.45}.\rho_L^{0.49}}{\sigma^{0.5}\lambda^{0.24}\mu_L^{0.29}\rho_v^{0.24}}$$

NOMENCLATURE

A	=	Surface area, sq. ft.
C	=	Heat capacity, B.Th.U./lb.°F.
P_v	=	Pressure corresponding to liquid superheat temperature, lb./sq.ft.
$P\infty$	=	Pressure on system, lb./sq.ft.
$\triangle T$	=	Temperature difference at boiling film, °F.
d	=	Tube diameter, ft.
g	=	Acceleration of gravity, ft./hr.^{2}
h_b	=	Boiling heat-transfer coefficient, B.Th.U./hr.sq.ft. °F.
h_c	=	Two-phase convective heat-transfer coefficient, B.Th.U./hr.sq.ft.°F.
h_L	=	Single-phase heat-transfer coefficient, B.Th.U./hr.sq.ft. °F.
k	=	Thermal conductivity, B.Th.U./hr.ft.°F.
q	=	Heat transfer rate, B.Th.U./hr.
y	=	Weight fraction of vapour.
β	=	Bubble contact angle.
λ	=	Latent heat of vaporisation, B.Th.U./lb.
μ	=	Viscosity, lb./hr.ft.
ρ	=	Density, lb./cu.ft.
σ	=	Surface tension, lb./ft.

Subscripts: L = liquid, v = vapour

It should be noted that these two approaches use quite different expressions for the Nusselt and Reynolds groups, and considerable further work is required to see which, if either, gives really useful results.

McNelly,[4] working mainly from considerations of dimensional analysis, has given an equation for nucleate boiling in the form

$$\frac{h_L d}{k_L} = 0.225\left(\frac{C_L\,\mu_L}{k_L}\right)^{0.69}\left(\frac{q/A.d}{\lambda.\mu_L}\right)^{0.69}\left(\frac{P\infty.d}{\sigma}\right)^{0.31}.\left(\frac{\rho_L}{\rho_v}-1\right)^{0.33}$$

These three equations by Rohsenow, Forster, and by McNelly have been compared by Mesler and Banchero[5] by plotting the temperature difference against the pressure for a fixed heat flux of 50,000 B.Th.U./hr.sq.ft., taking benzene as the liquid (Fig. 1). It is clear that there is little uniformity and, although Rohsenow's equation seems nearer the data, it is necessary to pick out a suitable value of his constant C_{sf}. Again these proposals show quite differing influences of the surface tension. Thus, if $h_b = \phi.\sigma^n$, then values of n from –2.5 to 1.275 have been proposed.

We cannot at present get a satisfactory picture, which is not altogether surprising when we are ignorant of what constitutes a nucleation centre. Relatively simple experiments show that the number of such centres varies in no clear way. More empirical expressions have been given by Cryder[6] and by Jakob,[7] Bonilla and Perry.[8]

In most evaporators the conditions are, however, rather different from the above, in that the liquid boils inside tubes and we are concerned with natural circulation with or without a climbing film action or with forced circulation. A liquid entering a tube is usually sub-cooled with respect to the boiling temperature at the base and only reaches its boiling point at some distance up the tube. The subsequent process is the passage of a two-phase system up a tube in which the proportions of the two phases are continuously changing. It is for this reason as well as others that the influence of the geometry of the system is complex and the correlations presented on the basis of studies in single tubes in which only an overall picture has been given have often proved misleading. McNelly[9] pointed out that the rate of heat transfer tended to increase up a tube and also increased with a reduction in

diameter. Kirschbaum, however,[10] does not regard the geometry as important. In any tube, and certainly in a long one, we have a combination of nucleate boiling arising from bubble formation and convection heat transfer arising from the increased velocity of the vapour stream. Such a system has inherently difficult properties, since certain parameters influence nucleate and convection boiling in different ways.

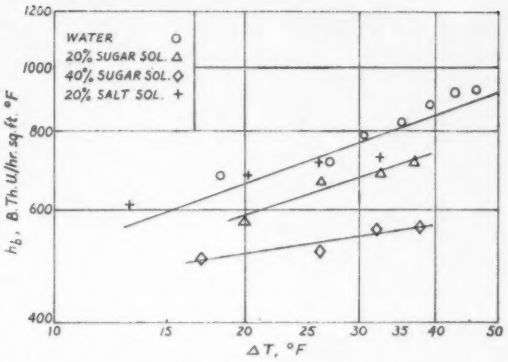


Fig. 3. Effect on h_b of several aqueous solutions.[13]

Boiling as two-phase flow system

Since the proportions of the two phases in a liquid boiling in a tube are varying, it would be advantageous to be able to measure the point value of the heat flux. Guerrieri and Talty[11] were two of the first to appreciate this and they have presented values for the point heat-transfer coefficient. This was made possible by using a very thick copper tube 0.375 in. thick and measuring the wall temperature and inside boiling temperature up the tube.

The point values of h_b increased along the tube even though the drop in temperature across the boiling film decreased. It follows that the percentage of vapour is a major factor in determining h_b. This can be put another way by saying that the high percentage of vapour corresponds to a high vapour velocity and that the convective nature of the process is important. The improved value of h_b as compared with single-phase convection is seen by plotting h_b/h_L against the percentage of vapour. The mechanism in the tube is regarded as mainly nucleate boiling at the onset but two-phase convection becomes predominant as the weight fraction of vapour increased.

In the two-phase region the coefficient is given as

$$h_c = 3.4\ h_L\left(\frac{1}{X_{tt}}\right)^{0.45}$$

where

$$\frac{1}{X_{tt}} = \left(\frac{y}{1-y}\right)^{0.9}\left(\frac{\rho_L}{\rho_v}\right)^{0.5}\left(\frac{\mu_v}{\mu_L}\right)^{0.1}$$

The combined heat-transfer coefficient h_b is then given by

$$h_b = 0.187\ h_c\left(\frac{r}{\delta}\right)^{-\frac{5}{9}}$$

where r is the radius of the minimum size thermodynamically stable bubble and δ is the laminar film thickness. It can be seen that in effect the contribution of nucleate boiling is shown by the factor

$$0.187\left(\frac{r}{\delta}\right)^{-\frac{5}{9}}$$

Dengler and Addoms[12] have tackled the problem of determining point transfer conditions in a rather different way. By adding manganese 52 with a half life of 5.8 days to water and tracing the radiation with a Geiger counter up the tube the proportion of vapour and liquid at any plane could be obtained. This enabled the heat flux to be plotted against the length of tube. The heat flux q/A increases steadily but much more strongly beyond 10 ft. even though the temperature difference remains reasonably constant. They explain the shape of this curve (Fig. 2) on the argument that in the first 10 ft. the heat transfer is predominantly nucleate boiling, but thereafter the nucleate boiling is suppressed and the transfer is mainly by forced convection of the two-phase mixture. This is in agreement with Guerrieri and Talty and clearly indicates the importance of forced convection. Over the region where nucleate boiling is suppressed they have essentially the same relation as Guerrieri and Talty:

$$\frac{h_c}{h_L} = 3.5\left(\frac{1}{X_{tt}}\right)^{0.5}$$

These workers also propose a complex correction factor to account for the nucleate boiling and again it is difficult to believe that their work provides a design technique, although it undoubtedly helps in formulating a picture of the process.

Guerrieri and Talty and Dengler and Addoms are arguing that the process is one of nucleate heat transfer till a certain flux is obtained when convective heat transfer is dominant, the high vapour velocity suppressing nucleation. McNelly also gave a similar argument for the different regions of heat transfer, but he was only able to plot length mean coefficients where Dengler and Addoms plotted point coefficients.

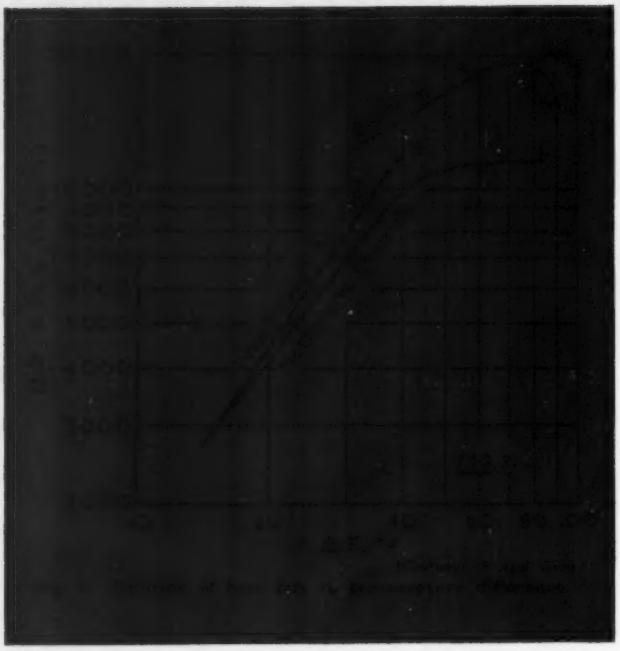
For boiling inside tubes we are still lacking a design equation, but there is some hope that recent work referred to above may lead to a much better understanding. In the meantime we must make judicious use of the practical data available. Work by Dunsmoir[13] looks likely to help in giving direct data on a usable size of equipment, and data from Whitt[14] are again useful. Whilst it is generally agreed that temperature difference is the predominating factor in nucleate boiling, it is not yet established whether a geometric term such as length is not also important in boiling inside tubes. Dunsmoir, using a 10 ft. by 1 in. stainless-steel tube gives results as indicated in Fig. 3.

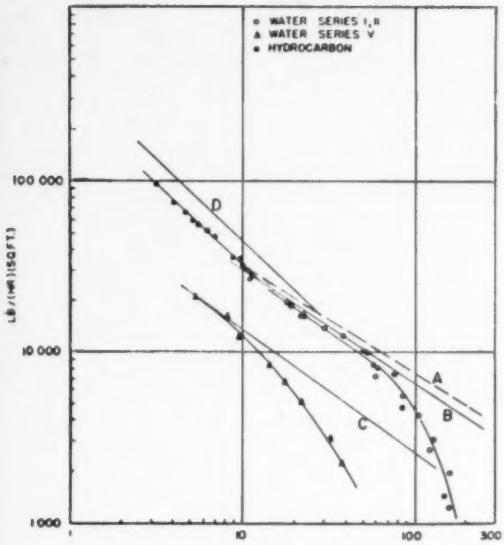
Industrial units

Data from industrial units are scarce and the paper by Whitt[14] is therefore particularly useful. He gives data for boiling solutions of methylene chloride in climbing-film evaporators of tube sizes $\frac{1}{2}$, $\frac{3}{4}$ and 2 in. diam., with the ratio of length to diameter kept at 100. The main tube material was silver and the liquor was heated by circulating water in an annulus. The heating film heat-transfer coefficient was taken from an equation given in the literature which was checked in a separate unit. By making overall measurements the boiling film transfer coefficient was calculated. Some of the results are given in Table 1.

Table I. Data for Boiling Solutions of Methylene Chloride in Climbing-film Evaporators (F. R. Whitt)[14]

Tube diameter, in.	$\frac{1}{2}$		$\frac{3}{4}$		2	
Feed rate, lb./hr.	81.7	84.6	78.9	94.2	92.5	93.5
Evaporation, lb./hr.	69.7	74.4	73.8	86.6	84.1	84.2
Heat flux, B.Th.U./hr.sq.ft.	10,004	10,713	10,629	12,474	12,116	12,129
Overall, ΔT °F.	56.0	56.7	52.4	54.9	53.7	52.5
U_B, B.Th.U./hr.sq.ft.°F.	180	189	203	226	216	232
h_B, B.Th.U. hr.sq.ft. F.	302	317	362	435	474	356
Boiling film, ΔT F.	33.3	33.8	29.1	28.7	25.6	35.6





[Courtesy: 'Chemical Engineering Progress']

Fig. 5. Comparison of observed and predicted recirculation ratios.[16]

On the whole he does not find substantial variations with the different tubes. Fig. 4 shows that his results are very much in line with those reported by Coulson and Mehta,[15] the slope of the line giving $q/A \propto \triangle T^{1.25}$. The maximum value of the heat flux obtained is about 12,000 B.Th.U./hr. sq.ft.°F., with a boiling film temperature difference of about 20°F.

These results are useful, but it is unfortunate that with industrial units it is very difficult to have control of the equipment so that the various parameters can be tested over wide ranges.

Circulation rates in thermosyphon units

For design purposes it is valuable to be able to predict the circulation rate in a natural circulation unit. A. I. Johnson[16] has given some data on these rates using a tube bundle of 96 tubes 8 ft. long and 1 in. i.d. He has shown that the rates can be predicted by a method due to Kern and the comparison of the observed with the calculated is shown in Fig. 5.

This problem has also been investigated at Glasgow by Thomson and Scott.[17] They used a large installation and have measured circulation rates where total vaporisation occurs. Some of the results are shown in Fig. 6.

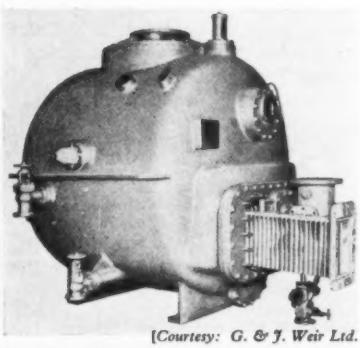
Scale

The problem of rapid scaling of evaporators continues to receive attention and a paper by N. O. Schmidt and W. S. Wise[18] is indicative of work done in the sugar industry. They discuss research on the use of EDTA (ethylene diamine tetracetic acid) for dissolving scale from calcium and magnesium salts. They also give some results on the use of sodium citrate. One useful piece of information is that the rate of cleaning of calcium sulphate scales is independent of *p*H above 6 so that very alkaline solutions of EDTA need not be used. Interest in chemical cleaning as opposed to mechanical cleaning lies in ease of application for large installations as well as in the doubt as regarding the effect of mechanical treatment on the tube walls. The use of external calandrias which are easier to get at seems to increase the capital cost rather too much at present, but this does seem a logical approach.

In the production of fresh water from sea-water a particularly troublesome scale is formed on the heated surface; to minimise this scale a recent development has been the use of the *Thermoflex* element in the latest Weir evaporator (Fig. 7). The element is fabricated from sheets of *Monel* metal deeply corrugated to give a large heating area and to make the element flexible. When the element is first put into service a thin but critical layer of scale will form; further deposits will be broken off by the flexing action of the element caused by normal variations in operating temperature.

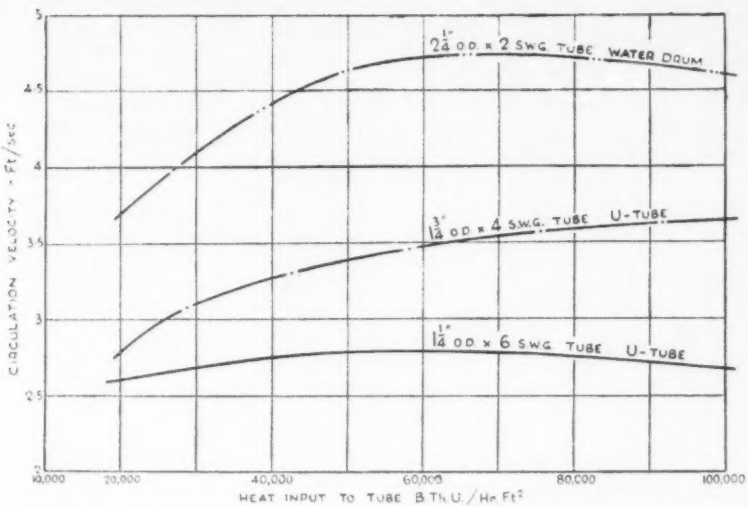
We are very short of accounts of the performance of commercial evaporators and data of this kind would be of considerable use in clearing up the known and unknown features of some of the typical evaporators. What liquid levels are used and can a distinct advantage be claimed for a definite level? Which units seem to be operating anywhere near the values given in many of the research papers on boiling liquids? Articles such as that on chemicals from wood[19] are interesting in showing processes and detail items of equipment, but these are touching the fringe of the subject.

Another article from the same



[Courtesy: G. & J. Weir Ltd.

Fig. 7. Horizontal evaporator with 'Thermoflex' element partly withdrawn from the evaporator shell. Scale shed by the element falls to the base of the shell and can be raked out periodically through the door shown beneath the element.



Tube: as indicated. Heating: uniform. Restricting orifice: none.
Tube positions: vertical. Heated length: 10ft. 6in. Pressure: 1,000 lb. per in.² (gauge)

[Courtesy: N.E. Coast Instn. of Engrs. and Shipbuilders

Fig. 6. Circulation velocity—heat input for various tube diameters.[17]

series[20] reminds us of the use of evaporators in the manufacture of organic material, this time pentaerythritol by the Hercules Power Co.

The problem of entrainment in evaporators has been discussed in an interesting thesis by D. B. Shearn[21] from Birmingham University.

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Submerged Evaporation

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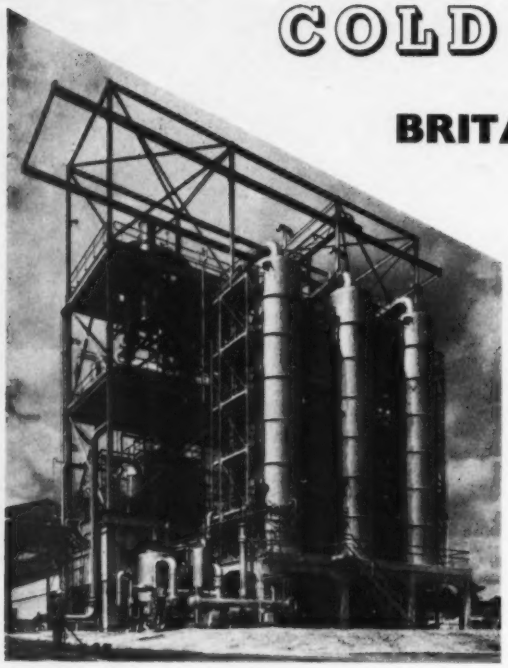
Olefin expansion at Grangemouth

Capacity for the production of olefins for the manufacture of petroleum chemicals by British Hydrocarbon Chemicals Ltd. will be more than doubled by the installation of a third ethylene plant at Grangemouth, Scotland, scheduled to be completed by the middle of 1960. The plant, construction of which was inaugurated recently with the driving of the first pile, will have a rated production capacity of 70,000 tons p.a. and it is believed that it will be the largest single ethylene plant anywhere outside the U.S.A. It will be similar to the two existing ethylene crackers and is estimated to cost, with its associated utilities and services, about £6 million.

The new ethylene project will bring total investment by British Hydrocarbon Chemicals (a joint undertaking of the British Petroleum Co. and The Distillers Co.) to over £30 million. Production of ethylene and other olefins began in 1951 and was expanded in 1956 with the completion of a second unit. The additional ethylene made available by the new plant will enable existing ethylene-utilisation plants, and the *Rigidex* polythene plant now under construction, to be operated at full capacity.

COLD RUBBER

BRITAIN'S BIG MODERN PLANT



The Hythe plant of International Synthetic Rubber Co. Ltd., situated just 1¾ miles from Esso's Fawley refinery on Southampton water, is now producing general-purpose styrene-butadiene rubber at the rate of about 50,000 tons p.a. and has a total capacity to produce 70,000 tons or more. Salient facts about the plant were noted briefly in our last issue; here is a description of the process.

Styrene stripping columns at Hythe.

THE Hythe plant, occupying a 54-acre site and with installations covering 280,000 sq. ft., produces S.B.R. (styrene-butadiene rubber)—more familiar hitherto as GR-S (Government rubber-styrene), especially in the U.S.A., where it was given this name at the time when the big synthetic rubber plants there were government-controlled.

In manufacturing rubbers of this type, the main reaction can be carried out either at about 120°F., to produce 'hot' rubber, or as low as 40°F. to produce 'cold' rubber. At Hythe, the butadiene/styrene copolymers are produced *via* a low-temperature, 'cold,' emulsion polymerisation reaction. This type of reaction has been made possible by the development of improved redox catalyst systems which contain both a reducing and an oxidising agent. These catalysts also enable polymerisation to be carried out more quickly than in the old 'hot' rubber processes. The two chief ingredients are used roughly in the proportion of three parts of butadiene to one of styrene; a heavy petroleum fraction may also be added at a later stage of the process if it is desired to produce an oil-extended rubber.

The main stages of the plant are the solution make-up stage, the reaction system where polymerisation takes place, the recovery system for removal and recycling of unreacted butadiene and styrene, and the finishing stage in which the rubber crumb is formed, dried and baled.

Solution make-up

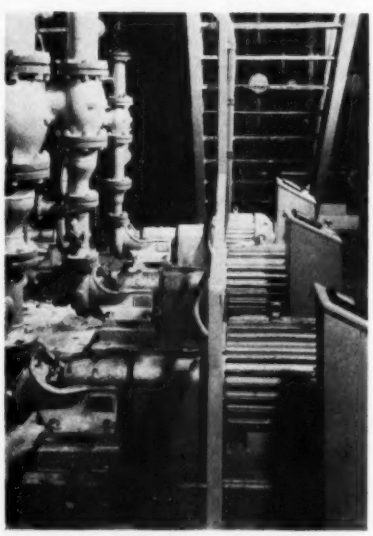
Fresh butadiene, which is received by pipeline from the nearby Esso oil refinery at Fawley, is blended with recycle butadiene. Excess recycle butadiene is returned by pipeline to the Esso refinery for repurification. The blended butadiene is pumped from the tank farm through a scrubber to remove the inhibitor. It is then pumped *via* surge tanks and metering systems to the reactor trains, as is also, from a separate tank farm, a blend of fresh styrene (brought by rail, road and sea from Forth Chemicals at Grangemouth and Shell at Partington) and recycle styrene.

Other materials pumped to the reactor trains include the emulsifier solution—prepared from rosin soap or fatty acid soap, and other materials, dissolved in water together—the activator solution, and the modifier.

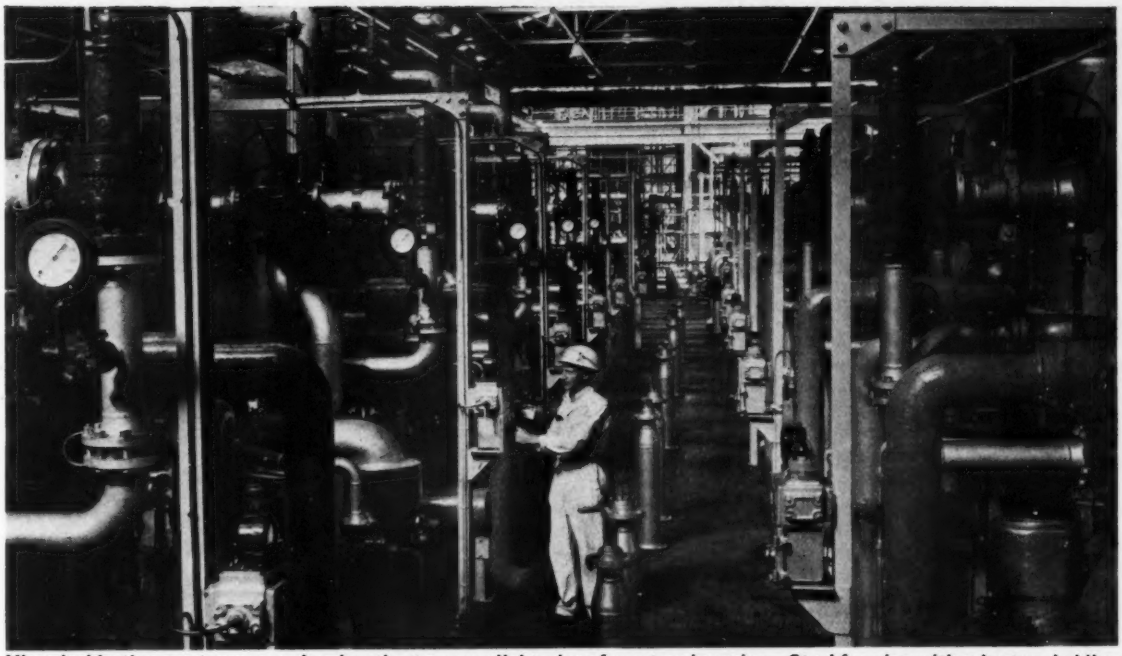
Polymerisation

The butadiene, styrene and various other solutions are combined together in a single charge pipe which passes through two series of exchangers, the first cooled by sea-water and the second by refrigerated ammonia. The outlet temperature of the charge stream from these latter exchangers is adjusted as may be required for the polymerisation reaction. At this stage the activator is added to the charge stream, which then passes to one of the reactor trains.

There are two parallel trains of reactors, 22 in all, each comprising a vertical mild-steel vessel of about 4,200 Imp. gal. capacity with internal cooling coils and a central stirrer, and the charge material passes from one vessel to another in series, polymerisation



Sigmund A-N heavy-duty chemical pumps on process duties.



View inside the reactor room showing the two parallel trains of reactors in series. Steel framing with asbestos cladding and glazing was used for the process buildings at Hythe.

taking about 10 or 11 hr. The whole polymerisation operation is continuous and the rate is controlled by varying the amount of activator solution and catalyst solution charged. The plasticity or Mooney viscosity of the polymer is controlled by the amount of modifier charged.

Polymerisation is arrested by the addition of 'short-stop' when it has proceeded to the desired degree. This is done in a series of displacement columns which succeed the reactor train. The latex then passes to any one of six glass-lined surge tanks where it is heated to about 120°F. by the direct addition of steam. In raising the temperature of the latex the vapour pressure of the unrecovered monomers is increased, thus facilitating their recovery.

Butadiene and styrene recovery

The hot latex, containing at this stage about 20% by weight of synthetic rubber and 10% by weight of unreacted monomers, passes first to pressure flash tanks where most of the butadiene is removed, and then to vacuum flash tanks for removal of the remainder. The butadiene vapour thus collected is compressed and condensed and pumped to the recycle butadiene storage tank.

The partially stripped latex now goes to perforated-plate columns where, by a process of steam stripping under vacuum, the unreacted styrene is removed. The styrene vapour/steam overhead streams from the columns are condensed and the styrene, separated from the water by decantation, is pumped to the recycle styrene storage tank. The latex is now completely stripped and passed to one of the stripped-latex storage tanks.

Finishing

The blended latex from the latex storage tanks is pumped to one of four blending tanks and at this stage oil emulsion may be added to the latex if it is required to produce oil-extended rubber. Anti-oxidant is also added in emulsion form to protect the rubber after coagulation when the wet crumb is being dried.

The latex now passes to the coagulation stage. This takes place under conditions of vigorous agitation. The resulting crumb and serum overflow into a second agitated vessel known as the soap conversion tank. From this latter the slurry overflows to a vibrating screen where the serum and coagulum are separated. The coagulum falls from the end of the vibrating screen into a reslurry tank where it is then washed by the addition of dilute filtrate from the filters.

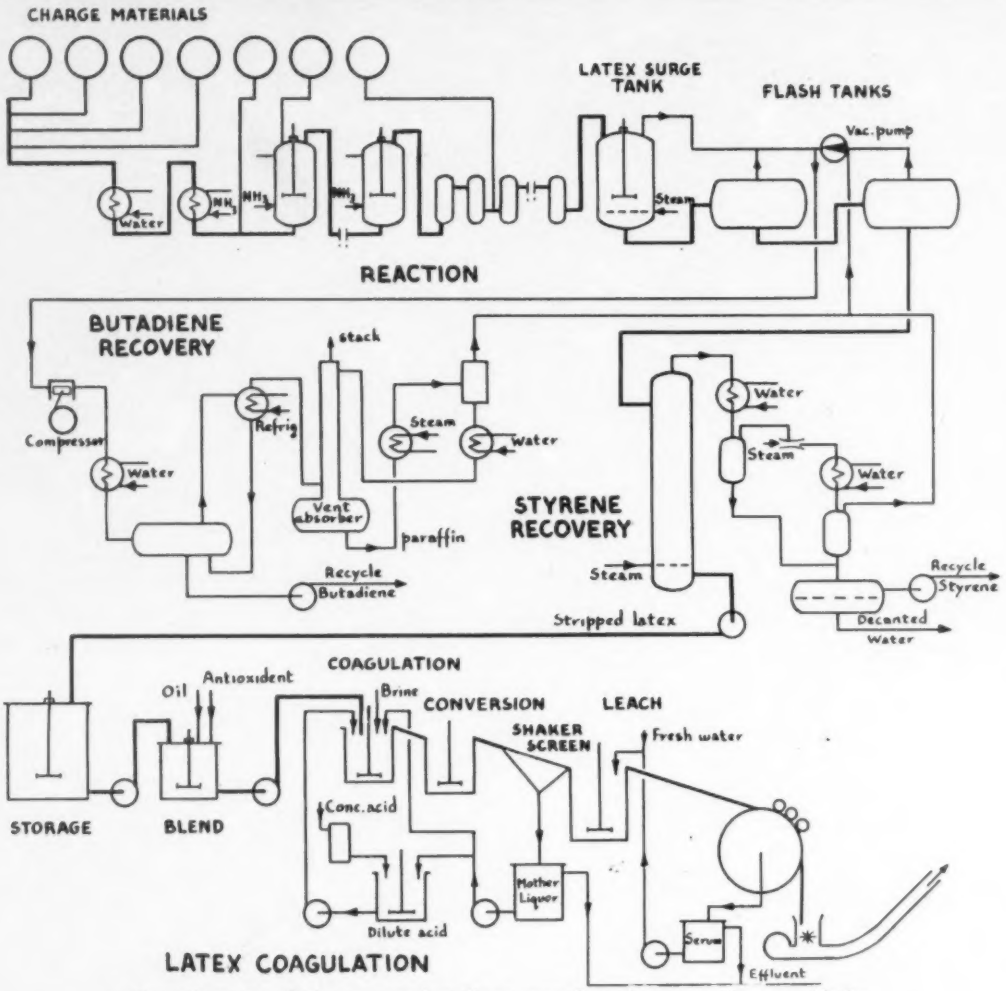
The slurry from the reslurry tank overflows to a rotary vacuum filter where the aqueous phase is removed partially by the action of the vacuum and partially by the action of externally applied squeeze rolls. The cake of rubber crumb then formed discharges to a hammer mill where it is broken down once more into discrete crumbs. These latter are fed pneumatically to the top conveyor of a three-conveyor drier. The moisture content of the crumb on entering the drier is of the order of 50 wt.% on the dry rubber and in passing through the drier the moisture content is reduced to approximately 0.5 wt.%.

From the discharge of the driers the rubber is fed *via* automatic weigh scales to balers which produce an 80-lb. bale of rubber. These bales pass *via* a metal detector to either film-wrapping machines or dusting machines and bagging machines. Finally the bales pass to the rubber storage building which is capable of holding 3,000 tons.

The plant capacity is handled by the finishing area by four trains of equipment in parallel, *i.e.* four coagulation tanks, four rotary vacuum filters, four driers, etc., until the baling stage is reached, when two-train operation is resumed.

Pumps and valves

In a plant of this type, which is reminiscent of refinery operations, pumps and valves are in evidence in large numbers for both manufacturing processes and site services. Of nearly



Flow diagram of the styrene-butadiene manufacturing operations at Hythe.

80 Sigmund pumps supplied, *Norma* pumps were selected for the large majority of process duties—these being redesigned single-stage, end-suction pumps, arranged to give maximum interchangeability of spares by standardisation of support frame and shaft assemblies to carry a wide range of impellers and casings. In the Hythe plant this standardisation has proved highly successul, since 80% of the *Norma* pumps in service have common parts with the exception of only five items. Where the service required it Sigmund A-N heavy-duty chemical pumps are installed and again 80% of these pumps have interchangeable shafts and bearing housing assemblies.

Chain - and - gear - operated *Audco* valves are in evidence on hydrocarbon gas lines, while intercoupled gear-operated valves form dual bursting-disc and relief valve sets in some process locations.

The products

The brand name given to I.S.R. synthetic rubber is *Intol*, the output being spread between three main types with differing properties. *Intol* 1500 has superior physical properties and is suitable for tyres and other hard-wearing applications, *Intol* 1502 has similar qualities but is almost colourless, while *Intol* 1710 contains aromatic oil and has easy processing characteristics.

Contractors and suppliers

Blaw-Knox Co., U.S.A., undertook the designing, installation and commissioning of the plant while definitive engineering and procuring was sub-contracted to Matthew Hall & Co. Ltd., London.

Sub-contractors and suppliers of plant and equipment included: Ashmore, Benson, Pease & Co., Audley Engineering Co. Ltd., W. P. Butterfield Ltd., Crane Packing Ltd., Dewrance & Co. Ltd., Enamelled Metal Products Corporation (1953) Ltd., Fisher Governor Co., W. C. Holmes & Co. Ltd., Richard Klinger Ltd., L. A. Mitchell Ltd., Murex Welding Processes Ltd., Newton Chambers & Co. Ltd., Permutit Co. Ltd., Redler Conveyors Ltd., Siemens Edison Swan Ltd., Sigmund Pumps Ltd., Staveley Iron & Chemical Co. Ltd., Stockdale Engineering Co. Ltd., Taylor Controls Ltd., United Kingdom Construction & Engineering Co. Ltd. and others.

The L s d of Chemical Engineering

SYMPOSIUM ON CHEMICAL ENGINEERING ECONOMICS IN LONDON

Are British chemical engineers too dependent on empirical methods when it comes to pre-design estimation of costs for chemical projects? Winding up a recent symposium in London, Dr. R. Edgeworth Johnstone (who himself outlined a statistical approach to cost estimating in his well-known paper to the Institution of Chemical Engineers in 1954) pointed out the surprising neglect of statistical treatment, which could make for much more reliable estimates. However, the symposium, organised by the Graduates' and Students' Section of the Institution of Chemical Engineers, showed that, while having to make do with a much scantier supply of cost data than is made available in America, British chemical engineers have plenty of ingenuity in devising ways of arriving at quick estimates. Here is a summary of the symposium.

THE symposium was extremely well attended and, although organised chiefly for the benefit of the graduates and students of the Institution, attracted a number of corporate members also.

Dr. E. H. T. Hoblyn, M.B.E., who presided over the first session, opened the meeting with a brief reference to the importance of costs to chemical engineers in all aspects of their work. He added humorously that this included the cost of the research chemist not being able to make his mind up soon enough.

How directors look at chemical projects

The first paper was by **Dr. J. W. Woolcock,** technical director of I.C.I. (Heavy Organic Chemicals) Ltd. He dealt with chemical projects from the point of view of the board of directors, who had to decide whether the project was chemically attractive. It was necessary, not only to ensure that the plant was economical at the time of going into operation, but also to look 20 or 25 years ahead—would the plant then be regarded as having been a good thing from the point of view of economy?

A common mistake was to err on the side of caution, and to build a plant too small, which could lead to economic difficulties in operation, or might show to a disadvantage if a competitor set up a larger plant which could then produce the product more cheaply.

The decision to go ahead with the particular project centred round the document that the chemical engineers and others concerned with the project presented to the board. The board would usually require, as a basis for decision, a presentation in a prescribed form of the relevant estimates of sales quantities and sterling realisation per unit; capital costs for plant, services and working capital; manufacturing cost; and finally the return on capital before and after charging depreciation or obsolescence. This document goes by various names, but 'appropriation proposal' is a useful descriptive term.

A board would, however, incur the risk of quite disastrous mistakes if it were to judge an individual project, or one project against another, by looking solely at the per cent. return and the possibility of finding the money. To do so would ignore the fact that what they have in front of them are estimates and not facts. Each figure has its own degree of uncertainty or 'probable error.' A purely formal document, containing a unique set of calculations, showing perhaps four significant figures, may conceal the fact that the inherent uncertainty in raw material price, or product realisation or in some other figure, may give a range of answers which vary from handsome profit to considerable loss. Additional studies have to be called for to ascertain how far one or more factors, taken individually or together, can conceivably take an unfavourable turn such as will put the project 'in the red.'

Dr. Woolcock then went on to reveal some of the 'tricks of the trade' in making these supplemental investigations. Thus, by making a simple correlation between fixed costs, and costs varying with output on the one hand, and sterling annual realisation on the other hand, it was possible to show the annual profit in pounds per annum that might be expected.

It was also desirable for the economics of the plant to be considered from the point of view of varying percentages of full output, taking into consideration both fixed and variable costs and the amount of profit that is likely to be realised.

The type of project to be particularly guarded against was the kind where profit margin was closely geared to the cost of raw materials. Such a project was very often a pure gamble if an estimate of this kind were relied upon, as the margin of error, while it might lead to a considerable profit, might equally well lead to a considerable loss.

On the subject of capital, Dr. Woolcock pointed out that it was difficult to obtain a quantitative estimate of what is too high a capital cost. He then demonstrated a simple graphical means (which might have a limited applicability) of correlating the ratio of annual turnover to plant capital, with the cost of raw material as a percentage of total cost, to show whether the project would be satisfactory or not.

Dr. Woolcock concluded that there are economical pitfalls in chemical projects which need at least as much study as the technical side.

Assessing the order of prices

In his paper **Mr. J. P. Asquith** (manager, engineering division projects, W. J. Fraser & Co. Ltd.) pointed out the desirability of assessing at the earliest possible stage of the project the order of prices which had to be dealt with. In considering the project, the cost of any additional provision for mains services must be considered, also the cost of engineering services, which would depend on the organisation and resources of the company concerned.

Mr. Asquith then referred to the much-publicised and misrepresented method of arriving at an early approximate estimate based on 'capital cost ratio.' His view was that this method should not be used except by someone who had sufficient experience to arrive at a figure by some other method anyhow.

Mr. Asquith considered that there was only one practical method lying between 'refined guessing' and detailed

analysis. He then described this method, which was based on breaking the project down into: plant items, pipework and valves, electrics, instruments, civil, site work, and engineering cost; and deciding, from records and experience, what percentage of the total cost each of these would represent. The cost of each of these items would then be estimated and added together to arrive at the total.

Mr. Asquith pointed out the value of building up a careful record of any cost data that might become available. The cost of various types of equipment could be obtained from various sources (*e.g.* by enquiring at exhibitions) and these could later be used in making comparisons, provided that the date applicable to that particular price was also noted.

Mr. Asquith concluded that there was no ready-made answer to estimating problems. It was a matter of experience and of using a system of careful observation.

Estimation of manufacturing costs

Mr. J. E. Cran (The Distillers Co. Ltd.) dealt with the estimation of manufacturing costs for project evaluation. Fifty or even a hundred economic studies may be needed before a project can be found on which full-scale development work is justified, and for this work to be done expeditiously unnecessary detail must be dispensed with; to preserve a basis of comparison a standard procedure is more or less mandatory. It is also important that the quantities which are estimated are clearly defined and that the definitions are thoroughly understood by the engineer preparing the valuation and the executive who has to give a decision on the basis of evaluation. To procure these objectives a *pro forma* is frequently used.

Mr. Cran illustrated a typical *pro forma* and explained the various items such as capital, labour, raw materials, maintenance, utilities, etc., for which provision would be made. As a flowsheet and some chemical engineering design would eventually be called for, it would be as well to base the capital estimate on flowsheet considerations. The usual procedure is to prepare a flowsheet and from material and energy balances about each item determine, as well as available data will permit, the size of each item of equipment. The equipment items are then priced on the bases of size and materials of construction.

To determine utilities requirements it is necessary to work from materials and energy balances around each item. Various allowances are made, where appropriate, for make-up losses, loss of heat by radiation, etc. On the *pro forma* the quantities of utilities, their unit costs and the total annual cost and cost per ton are entered.

Turning to direct process labour, Mr. Cran pointed out that when making the first assessment the engineer was unlikely to be in a position to carry out an elaborate analysis of labour requirements. At this point, therefore, the flowsheet was divided up into a series of stages. For those stages which are likely to be critical or difficult, such as reactors or batch operations, allowance should be made for one man full-time; for the recovery operations such as distillation, absorption, extraction, filtration, etc., the allowance should be from quarter to half a man per unit. The flowsheet and some operating experience will provide the necessary clues.

The cost of materials and labour required for maintenance would be proportional to the amount of equipment to be maintained and was usually estimated as from $2\frac{1}{2}$ to 10% of the total fixed capital. From there on the variables affecting maintenance costs are difficult to assess. The handling of corrosive materials, high temperature and high pressure may add to maintenance costs.

It is not always easy to know what unit prices to allow for certain raw materials; the figures used should be as realistic as possible because raw materials costs can often be determining.

A return on capital can be calculated by deducting operating cost from selling price and expressing this as a percentage of capital. If 15% net was taken as a reasonable return on investment and an allowance made for tax it would be found necessary to work to a gross return (before tax) of 26%. The return on capital should then be calculated as 26% of the sum of total fixed capital and working capital.

Mr. Cran went on to deal with capital charges and discussed the problems of assessing the amount of depreciation or amortisation.

Process selection economics

The economics of selecting a process was dealt with from the point of view of the general engineering industry in the paper by **Mr. A. G. B. Owen,** C.B.E., chairman of Rubery Owen & Co. Ltd. He focussed in particular on the changing of an existing method of production to increase efficiency and reduced operating costs, taking as an example the manufacture of axle cases by his company.

On the question of deciding on the justification for a new process Mr. Owen said all the necessary and relevant facts and figures must be presented in an acceptable manner and corroborated—more projects had been turned down through bad presentation than through not being justified by the subject matter.

Mr. Owen discussed the economics of a new special-purpose machine for a particular machining operation in his company, then touched on the subject of overhead costs and showed how cost varies with the volume of output. The importance of the break-even point was referred to and it was pointed out that the greater the value of the equipment employed in the factory, the higher will be the fixed expense and, consequently, the higher the break-even point.

The various activities involved in implementing a new process, usually co-ordinated through the production engineer, required for speed and efficiency the complete briefing of all levels of staff beforehand. Finally, Mr. Owen pointed out that the ultimate responsibility must rest with the board or the managing director.

Market research

Mr. H. Munt, of the marketing research division of Unilever Ltd., explained the application of market research to production planning. Production, he said, was related to sales possibilities and the high fixed costs of plant, coupled with the danger of technological developments leading to possible product obsolescence, together with the high investment costs in raw materials, product development, administration and marketing, make careful planning on the basis of estimated sales essential.

In some industries, as for instance those producing certain types of household consumer goods where demand and consumption is regular throughout the year, plant could be continuously employed at an even rate in parallel with consumer offtake. This type of situation was the easiest to deal with where market research techniques had successfully been employed to measure the extent of market consumption by volume and by rate of consumption.

Other production situations arose where raw materials become available only at certain times of the year and had to be processed within a short period of time, or where demand fluctuated, as for instance according to

the weather, or again where consumption was purely seasonal, resulting in peak periods of demand. In such cases the mechanics of production planning became more complicated, especially if the product deteriorated in storage, but the basic requirements remained the same, namely, knowledge of present and potential market requirements.

The sources of information varied according to the industry and the type of product. In some cases quantitative estimates of total markets were readily avilable in terms of production; in others little or no attempt had been made to prepare reliable statistics of the trade. Where it had been established, information relating to the share of the trade held by individual manufacturers was usually unpublished or available only by private subscription to its authors.

In the case of industries concerned with capital goods or intermediate products, survey work was possible amongst manufacturers to discover the extent of use of such intermediate products used by them in the process of producing their finished product. In some cases consumption of the intermediate product could be deduced from figures of production of the finished product. The market researcher must use all sources and all possible approaches to check and recheck his findings.

Instrument costs

Dr. D. W. Gillings (Imperial Chemical Industries Ltd.) dealt with the cost of instrumentation and control installations. Typical orders of magnitude of cost of complete control installations were given, showing that the whole system is usually in the range 5 to 15% of the complete plant cost. Some probable ranges of costs including installation were given in the following tabulation:

Type of unit	*Probable installed price range* (£)
Flow-recording controller system*	400—500
Flow switch	50— 80
Level indicator†	100—200
Level recorder†	150—250
Level-recording controller system*	400—500
*p*H indicator†	350—450
*p*H-recording controller system*	500—700
Pressure controller	50—200
Pressure indicator	10 upwards
Pressure-recording controller system*	400—500
Speed indicator†	50—150
Temperature recording controller system*	500—600

* System includes pneumatic pipework, 1-in. valve (not special type) with pneumatic actuation.

† Installed costs take account of accessories as well as installation.

A progressive change from pneumatic to electronic controllers, and a widespread increase in the use of direct analysis instruments, were given as examples of present trends, with the introduction of data logging and processing and ultimately on-line electronic computers as longer-term developments. A brief analysis was given of problems in assessing economic return, and Dr. Gillings pointed out that process data were not always readily available for such assessment, but as it should in future be possible for more data to be obtained from more comprehensive instrumentation, these problems would become less formidable.

In conclusion, it was pointed out that an economic analysis of the control system cannot be complete if considered in isolation, and that such studies must be ancillary to good progress in technical innovation.

Capital costs of vessels and equipment

It is a hazardous business to put forward in public cost estimates for equipment in which there is such a high degree of competition as exists in the process plant fabrication industry today. So it was pointed out in the paper presented by **Mr. B. Pollard** (Constructors John Brown Ltd.) which nevertheless provided a valuable guide to the order of prices for various classes of storage tanks, process vessels, heat exchangers and distillation equipment. Figures were presented as representing an average for the U.K. fabricating industry, and the point was made that, in assembling such figures, one must try to take into account not simply the cheapest price but a normal price that one would expect to pay, consistent with good-quality workmanship and reasonable delivery.

Approximate fabrication costs were given, on a price-per-ton basis, for storage and pressure vessels in mild steel, stainless steel and aluminium, while it was pointed out that, for mild-steel process vessels, the fabricating cost varies with the type of internals, complexity, pressures, workmanship, etc., but would be in the range of £240 to £450/ton. Relative cost factors of 1.0 for mild steel, 2.0 to 2.5 for aluminium and 2.5 to 3.0 for stainless steel were given.

For mild-steel heat exchangers of the simple, low-pressure, fixed-tube plate type up to 50 p.s.i.g., it was shown graphically that the price/sq.ft. varies from 13s. for the large ones to 100s. or more for small ones. It was explained that these exchangers had been designed down to the duty called for in order to keep the price at a minimum and were used in small chemical plants on various duties. For 'T.E.M.A.'-type heat exchangers of 150 p.s.i.g. the price was shown to vary from 28s. to 120s./sq.ft. and higher, based on a floating-head type, whereas fixed-tube plate types would be 10 to 20% cheaper. It was also shown that, in the case of the T.E.M.A.-type exchanger, the effect of varying tube length has a greater effect on the cost per sq. ft.

For distillation columns it was acknowledged to be almost impossible to give comprehensive cost data, owing to the many different types of plates in use. However, for smaller jobs where packed columns are employed, it is simply a matter of multiplying the basic cost of the ring pack by the number required. These rings are produced in such large quantities that the price does not vary very much with quantity. Approximate prices per cu. ft. for porcelain rings, depending on quantity, would be 15s. for 2-in., 18s. for 1½-in., 25s. for 1-in., and 67s. for ½-in. rings. If these figures were taken as a base of 1.0, the factor for mild steel would be 2 and for stainless steel about 10.

Pumps and fans

Chemical engineers generally are more familiar with pumps and their performance than with fans. A useful guide to the selection and cost of centrifugal fans was given in the paper by **Mr. H. W. Thorp** (Chemical Engineering Department, University College, London). An important factor in selecting a fan was the capital cost as compared with the running cost and taking the load factor into consideration. The size of the fan would depend on the duty, speed and type of impeller required, as well as on the location and space available. Materials of construction also had to be considered, according to the gas to be handled, while further important points were the method of drive to be used and how soon delivery was required, stock types being more readily available than tailor-made units.

As a basis for cost comparison, Mr. Thorp considered

a fan to handle 10,000 cu.ft./min. of clean, cool air at 2 in. water-gauge; the approximate cost would be: with f.b. paddle-blade impeller, speed 730 r.p.m., efficiency 60%—£100; with b.b. fan at same speed, 70% efficiency—£200; and with an aero-foil-section blade, same speed, 80% efficiency—£250.

If a higher water-gauge was required, power requirements would increase and hence efficiency was of paramount importance, especially if the load factor was high.

For cool, clean gas a smaller, multi-blade fan was better than other types. Dust- and mist-laden gases called for more robust construction and a paddle-blade impeller suitably strengthened to combat dangers of erosion, corrosion or build-up of solids. The extra cost would amount to approximately 20%.

For fans at ground level it was best to use small units on a concrete plinth when high speeds could be used. If a fan must be sited on a steel-frame structure it was best to use a larger fan running at a lower speed. This involved a more costly fan and motor with lower efficiency, which would more than outweigh the cost of bringing ducting to a small high-speed fan at ground level where accessibility is better.

Turning to materials of construction, Mr. Thorp stated that fans for handling cool, clean air were usually made in mild-steel. He observed that where weight was a consideration, however, other materials came into use. In very large fans high-tensile steel was used for the impeller to give rigidity under load without undue weight, the extra cost being in the region of 15%. For a stainless-steel shaft, impeller and casing for handling corrosive gases, the cost would be some four times that of a mild-steel unit. For cool, corrosive conditions rubber or PVC coating could be used, the cost then being about twice that of mild steel.

The V-belt was the commonest and cheapest type of drive. A direct drive with flexible coupling would increase the cost to about 1.15 that of the ordinary V-belt unit, while the need for a variable-speed drive might call for the use of variable-speed motor, a fluid coupling, or inlet-vane control, the cost multiplying factor being 2.5, 1.75 and 1.5 respectively.

On the subject of pumps, Mr. Thorp pointed out that similar considerations applied as for fans, but there were not such a variety of impellers for pumps as there were for fans. As a basis for cost estimation, one could take a pump handling clean water at 100 gal./min. and 50 ft. delivery head. A 3-in. pump with closed impeller and end suction, all of cast-iron construction, would cost about £30. A bronze impeller would raise this to £50.

For slurries, sewage, sugar beets, fish livers, etc., a special, robust type was needed with open impeller and the front hinged for easy cleaning. For a 3-in. pump with end suction and an efficiency of 1,450 r.p.m. of 45% the cost would be some £110, making allowance also for a high-tensile steel shaft sleeved in stainless steel. A tailor-made impeller for the same pump would add about 17 to 20% to the cost, while if the whole pump was in bronze the cost would be doubled.

For chemical plant handling very corrosive liquids pumps could be made of high-silicon iron at an approximate cost ratio of 3 to 4.

Thermal insulation

Introducing his subject as the 'Cinderella' of the engineering profession, **Mr. J. C. Stainton** (National Fuel Efficiency Service) said that thermal insulation, or lagging, was nevertheless a means of saving money. The extent to which thermal insulation should be carried out was determined partly by physical requirements but largely by the balance between the cost of applying and maintaining the insulation, and the value by way of the fuel saving involved.

The insulation of factory buildings could produce economies, *e.g.* by making possible reductions in capital cost—up to 60% in some cases—of boiler plant, space-heating systems and boiler-house structure. Other economies thus obtained included the reduction of preheating losses arising from recovery after week-end or overnight shut-down, reduction of the heat requirement during working periods and reduction of lost production due to unsatisfactory working conditions.

On pipelines, Mr. Stainton drew attention to the practice of leaving bare a pipe serving process plant on the grounds that it also serves as a space heater. This was wrong, as it meant that the pipe was wasting heat during the summer-time; the process steam distribution system should always be kept separate from the space-heating pipework.

For insulating a pipe, the economic thickness was that thickness at which the sum of the insulation cost and the cost of the heat loss over a given period of depreciation is a minimum. Mr. Stainton discussed at some length two methods of making this calculation as described in British Standard Specification 1588: 1949, and gave worked examples. In one example, an insulating material (K = 0.48) was to be applied to a 6-in.-bore pipe containing steam at 500°F. The insulation was required to pay for itself in five years, working 8,000 hr. p.a. The steam was generated at 70% efficiency from coal having a calorific value of 12,500 B.Th.U./lb. and costing 100s./ton. Calculations showed that the least expense over a period of five years would be obtained by applying a 3-in. thickness of insulation.

Mr. Stainton pointed out that 8,000 hr. p.a. represented almost continuous operation. When intermittent heating was practised a further factor had to be taken into account, arising from the storage of heat within the insulating material itself. On each occasion that the pipe was heated, heat would be added to the insulating material until a steady state was achieved, and this would be dissipated after the pipe started to cool down. The combined result of this factor and the reduced number of hours of service would mean that the final increment or increments of thickness could not be justified and the economic thickness of insulation would be less than for continuous operation.

On the subject of vessels, Mr. Stainton said that the covering of open vessels might be considered as a form of insulation. The advantage of this went beyond thermal insulation, since, by maintaining the atmosphere above the liquid in a saturated condition, excessive evaporation was prevented. The method of finishing the insulation of vessels should also be considered from the standpoint of economy.

£ s d

CPE CHEMICAL PLANT COST INDICES

Cost indices for the month of October 1958 are as follows:

Plant Construction Index: 177.7
Equipment Cost Index: 164.3
(June 1949 = 100)

£ s d

Discussion

Mr. J. E. Cran said that in his company they had used a method of estimating similar to that described by Mr. Asquith, starting with consideration of a flowsheet, and it was found necessary to add a contingency to plant items.

Mr. Asquith said that failure to include a complete picture of the number of plant items in the flowsheet led to the necessity for making appropriate adjustments to the cost of associated pipework, etc. Also, sometimes an item appears in the flowsheet as a standard type of equipment, but was subsequently found to call for special equipment, with a corresponding increase in cost.

Another speaker pointed out that the contractor's estimate often overlooked the 'services to contractor' item. The estimate was often based on the provision only of skilled labour, and did not take account of unskilled labour. The 'interest on capital' should also be included in a cost estimate.

Mr. Asquith assured the speaker that in his company there was a system to ensure that no item is overlooked. There was a special form to be filled in and which catered for all likely items.

Mr. Lee (British Petroleum) said that a matter that had not been discussed was the intricate widespread effect of a project on other projects—should this not be included in assessing prospects of a particular project?

Dr. Woolcock replied that these matters were taken into account. For instance, the document submitted to the board would show how much old plant capital would have to be written off. In the case of a new project providing the supply of raw material to another division of the company, there was suitable co-operation in the planning stage. There was similar co-operation in the event of a new plant making obsolete the facilities of another division.

A speaker pointed out that while, on the one hand, Dr. Woolcock had indicated a careful assessment of a new project from all aspects, on the other hand Mr. Asquith had given rule-of-thumb methods of estimating. Would Dr. Woolcock accept that method of estimating?

Dr. Woolcock replied that a board was concerned with estimates at a variety of stages of a project. The quick estimate was only a part of the procedure; the type of estimate described by Mr. Asquith usually occurred at a fairly early point in the contracting stage. The quick estimate had its place, but in considering expenditure proposals more detailed examination was necessary.

Mr. Asquith confirmed that the quick estimate was only a preliminary procedure. No estimate of this sort would normally be put forward by a contractor as a serious proposition and as a base for a project.

Dr. Woolcock was asked whether his board had any method of keeping before them during the progress of the project any deviations from the original estimate. Dr. Woolcock assured the speaker that any expenditure over the estimate had to be answered for.

Answering a question about a point made in his paper, Mr. Stainton said he had not meant to convey that replacement of lagging for the pipes would be necessary after five years; only that extensive maintenance would not arise during that period. Lagging would, as a general rule, last much longer than five years.

Answering a further question as to whether it was possible to estimate accurately the heat losses from outdoor tanks, Mr. Stainton replied that the loss from outdoor tanks was subject to so many variable factors (exposure, wind velocity, etc.) that the losses could not be determined accurately. If the calculations are based on still air conditions one can be certain that the economy to be effected will not be exaggerated.

Mr. Kincaid (Hygrotherm Engineering) asked if Mr. Stainton could suggest an insulation that could operate both above and below ambient temperature, say in the region 0 to 400°F. Mr. Stainton's reply was to the effect that it is difficult to put forward a single insulating material suitable for the range between 0 and 400°F. This is due to the fact that difficulty is experienced in the lower ranges when the cold surface of the insulation is below the dewpoint of the surrounding air and that portion of the insulation which is below dewpoint tends to become moisture laden with the fibrous types of insulation used for the higher temperatures. A difficult situation is created, particularly if the surface being insulated is of a corrodible nature. It is possible to use magnesia throughout the temperature range in question, but for low temperatures it is essential to provide a vapour-proof finish so that atmospheric moisture can be excluded. On the other hand, cork is quite commonly used for low-temperature insulation, but is unsuitable by its nature for use at temperatures above about 180°F.

Referring to cost figures given in Mr. Thorp's paper, Mr. P. M. Davison (L. A. Mitchell Ltd.) said, while he was sure Mr. Thorp had obtained his data from fully reliable sources, the prices for acid-resisting pumps seemed a little unfair to pump manufacturers, being on the low side, especially in view of the fact that most engineers require such pumps to be fitted with mechanical seals which are themselves fairly expensive.

Chairman's conclusions

Dr. R. Edgeworth Johnstone, who presided over the final session of the symposium, reviewed the main points that had emerged from the papers and discussion. He pointed out that these had covered three main topics: cost estimation, cost control and market research.

Cost estimation had been the predominant topic. It was fairly evident that as a science—or even as an art—cost estimation was still very much in the empirical stage. Nothing much had seemed to emerge in the way of new principles and new methods. Dr. Edgeworth Johnstone reminded his audience that cost estimation was susceptible to statistical treatment and he was surprised that no one had yet dealt with the subject on these lines. What was needed was an estimate of the reliability of a cost estimate; for example, confidence limits.

Dr. Edgeworth Johnstone said that a useful idea described by one speaker (Mr. J. Cran) was the use of a standard estimating form. Very often under-estimation occurred not so much because of errors in particular items as because some item or items had been omitted.

On cost control, the utility of the 'break-even' curve had been confirmed by various speakers. The correct allocation of overhead costs was always a problem, and Dr. Edgeworth Johnstone mentioned the marginal costing system as of interest to engineers.

Of market research, Dr. Edgeworth Johnstone said that, while not so much had been heard about this subject during the meetings (no doubt because it lay outside the immediate scope of the practical engineer), it was a subject that was becoming more important and developing more reliable techniques.

Addressing himself to the graduates and students who formed the bulk of the audience, Dr. Edgeworth Johnstone advised them to start keeping a notebook in which all price information was recorded. In a few years such a notebook would become a valuable asset to the chemical engineer.

ANALOGUE COMPUTERS IN CHEMICAL ENGINEERING—2

Applications of a General-purpose Analogue Computer

By D. S. Terrett, B.Sc.
(*Fairey Aviation Co. Ltd.*)

In the first article of this series, which appeared in October, the various basic units performing standard mathematical functions in a general-purpose analogue computer were discussed. These units may be arranged by suitable interconnection to solve a wide range of problems in the mathematical and engineering field, as this article explains.

GENERAL-PURPOSE computers can be used either to analyse given equations or to synthesise systems. They are in many cases the only practical route to a satisfactory solution of problems, particularly where relationships between variables are non-linear or otherwise undeterminable. Typical applications to which these computers are being applied are:

(*a*) Control of chemical and process plants.
(*b*) Control of nuclear reactors.
(*c*) Control of grouped power station loadings.
(*d*) Analysis and synthesis of non-linear servo-mechanisms.
(*e*) Synthesis of auto-pilots, navigation systems and training aids.
(*f*) Vibration and flutter of structures, turbine blades, helicopter blades, turbo propellers, gear teeth and transmission systems.
(*g*) Network and filter design.
(*h*) Ballistic and flight trajectory problems, general problems of kinetics and kinematics.
(*i*) Heat flow and diffusion problems by simulation and computation.
(*j*) Fourier analysis.

In all these fields where precise design is obligatory the computer clarifies the problem and reduces the cost and time for satisfactory solution.

In the following paragraphs the applications of the general-purpose computer are described with particular reference to design problems associated with the synthesis and automatic control of industrial and chemical process plant.

Setting up a problem

When using the computer as a differential analyser the given physical problem is generally stated in equation form together with the values of the constants and the expected or relevant range of the variables.

The first step in the preparation of the problem for the computer is to rearrange the equations to make the best use of computing elements, for example by the use of implicit computation where the unknown input voltages are treated as if they were known, and the desired differential equations are set up by means of a set of feedback connections. This, for instance, allows the use of integration units which are more accurate than differentiation units.

The rearranged equations should now be represented by computing elements drawn in a block diagram showing the interconnections between the various units.

It is next essential to establish a transformation between the original variables in the problem and the voltages which simulate these in the machine. As the machine voltages are

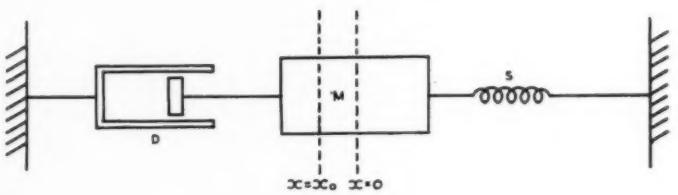


Fig. 1.

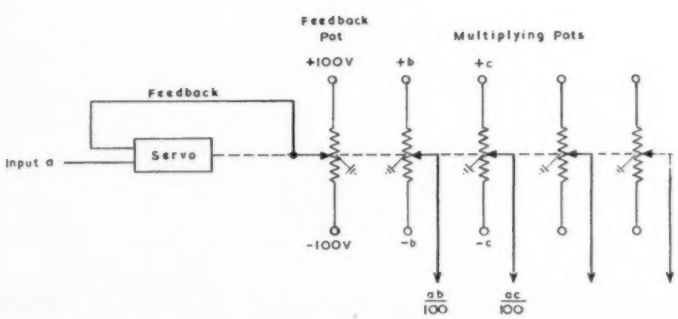


Fig. 2.

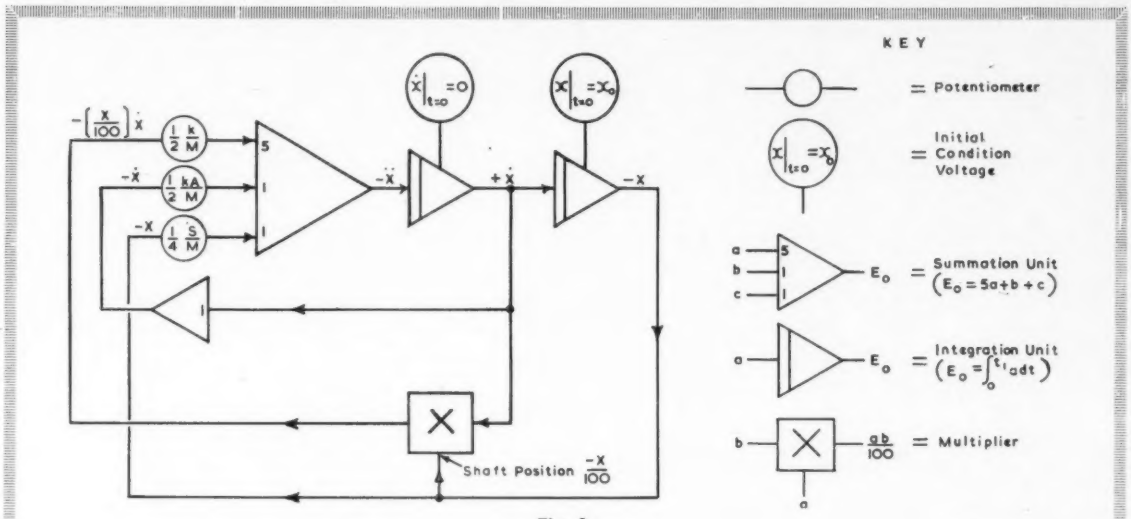


Fig. 3.

generally restricted by design considerations to a little over 100 v., it is convenient to measure the machine variables in units of 100 v. If, for example, the maximum excursion of a particular variable is 10 units, then it is quite safe to allow 10 v. on the machine to equal one unit. These dimensional coefficients (in this example, 10 volts/unit) are known as scale factors.

A facility of the analogue computer is that changes of time scale may easily be made—that is, a process may be speeded up or slowed down—on the machine to obtain the best performance from amplifiers or moving mechanical elements such as servo multipliers and recorders. A convenient method of setting the time scale is to first determine the values of coefficient potentiometer settings, then adjust the time constants of all the integrators to suit the time scale chosen.

The block diagram can now be redrawn for the specific problem with selected amplifier input resistors, potentiometer settings and integrator time constants to conform with the scale factors and time scale chosen.

Initial conditions voltages corresponding to the initial values of the variables at time $t = o$ may be injected into the appropriate units in the computer set-up.

To illustrate these principles let us consider their application to the simple problem illustrated in Fig. 1. It is a mass fixed on the one hand to the spring S and on the other to the damper D which has a non-linear characteristic of the form $K(x + A)$, where both K and A are constants and x the distance from the neutral position. If the mass M is constrained from the neutral position and released at $t = o$ the equation describing its motion at time $t > o$ is

$$M\frac{d^2x}{dt^2} + K(x + A)\frac{dx}{dt} + Sx = 0 \quad \ldots(1)$$

where at $t = 0$ $\dfrac{d^2x}{dt^2} = 0$

$$\frac{dx}{dt} = 0$$

$$x = x_o$$

Arranging this equation so that the highest derivative is on the left-hand side:

$$\frac{d^2x}{dt^2} = -\frac{K}{M}(x + A)\frac{dx}{dt} - \frac{Sx}{M} \quad \ldots(2)$$

If the estimated maximum values of the variables in equation (1) are

$$\left|\frac{d^2x}{dt^2}\right| = 20 \text{ ft. sec.}^{-2}$$

$$\left|\frac{dx}{dt}\right| = 10 \text{ ft. sec.}^{-1}$$

$$|x| = 5 \text{ ft.}$$

and the machine unit is ± 100 v., then suitable values of scale factors are

5 v. ft.$^{-1}$ sec.^{2} for $\left|\dfrac{d^2x}{dt^2}\right|$

10 v. ft.$^{-1}$ sec. for $\left|\dfrac{dx}{dt}\right|$

20 v. ft.$^{-1}$ for $|x|$

Hence if d^2X/dt^2, dX/dt and X are the machine voltages corresponding to the variables d^2x/dt^2, dx/dt and x, we have

$$\frac{d^2x}{dt^2} = \frac{1}{5}\frac{d^2X}{dt^2} \qquad \frac{dx}{dt} = \frac{1}{10}\frac{dX}{dt}$$

and $$x = \frac{X}{20}$$

Since the multiplication of variables is involved in the solution of equation (1), the scale factor of the multiplier has to be taken into account. Referring to Fig. 2, if two voltages a and b are multiplied together, the resultant output of the multiplier will be $a \times b/100$ volts with 100-v. machine unit.

Substituting in equation (2) for d^2x/dt^2, dx/dt and x, and multiplying out we get

$$\frac{d^2X}{dt^2} = -\frac{5K}{20M}\left(\frac{X}{100}\right)\frac{100}{10}\frac{dX}{dt} - \frac{5K}{M}A\frac{1}{10}\frac{dX}{dt} - \frac{5SX}{20M} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$$\frac{d^2X}{dt^2} = -2.5\frac{K}{M}\frac{dX}{dt}\left(\frac{X}{100}\right) - \frac{1}{2}\frac{K}{M}A\frac{dX}{dt} - \frac{1}{4}\frac{S}{M}X \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Using the method of implicit com-

putation (*i.e.* we assume that we know the quantities X and dX/dt), a block diagram of the machine set-up may be derived using equation (4). This is shown in Fig. 3.

The equation (4) gives all values of dial sets and the multiplier shaft position.

In setting up the above problem it has so far been assumed that the computer is working in real time, that is τ units of machine time $= t$ units of actual time. Sometimes, however, it is necessary to change the time scale of the problem (slow it down or speed it up) for convenience of observation or recording. The time scale may be established by writing a transformation equation relating the machine time to actual time, *i.e.* the independent variable in the problem.

$$\tau = \alpha t \quad \ldots\ldots\ldots\ldots \quad (5)$$

$$\therefore \frac{d}{dt} = \alpha \frac{d}{d\tau} \quad \ldots\ldots\ldots \quad (6)$$

From (6) it follows that change of time scale may be considered as a change of gain on all the integrators. For example, if it is desirable to speed up the problem outlined in equation (4) by 10 times it is only necessary to increase the gain of each integrator input 10 times; no change of coefficient potentiometer settings is necessary as this change of integrator gain may be accomplished by reducing the value of the feedback capacitor by 10 times.

The wiring layout, the coefficient potentiometer settings and the gains of the various units required to solve the above problem have now been determined. Before a computer run is started, however, it is necessary to establish at the output of each integrator in the problem ' set-up ' a voltage equal to the initial value of the machine variable which is to appear at that point. These voltages are shown in the problem wiring diagram in Fig. 3.

Having set up the computer in this fashion it is possible to determine the response of the mass M to various inputs—for example, its recovery after an initial displacement—and it is possible, for instance, by charging potentiometer settings, to vary the coefficients in the equations to optimise the system for minimum overshoot and recovery time. Similar investigations involving the solution of non-linear equations are extremely tedious and often impossible if normal manual computational techniques are used.

Simulation techniques

Although many important design problems may be solved using the techniques described above, in some cases, however, particularly those found in the design of industrial and process plant, it is impossible to write down a set of differential equations describing the whole system. Generally the system may be broken down into a number of cascaded and paralleled components. These components will either have transfer functions governing their output and input relationship which may be simulated with standard computer units in terms of voltage, or arbitrary or special characteristics which may be simulated in the computer with function generators, multipliers, clamps, dead space generators, etc. Having derived a method of simulation of each component using computer units, these simulated components can be connected together according to the flow diagram of the plant or process, to provide an electrical analogue of the complete plant.

As an example let us examine the simple process control loop shown in Fig. 4. Blocks A and C are different parts of the process that may be represented with sets of differential equations; connecting these is block B, which represents the transport lags produced by the connections between the two sections of the process. D is an output sensing device such as a thermometer whose output is compared with a reference F in the error detecting device E. The error then feeds into a controller, which may be a conventional three-term device, which in turn operates an actuator and control valve G.

Fig. 5 shows the flow diagram of

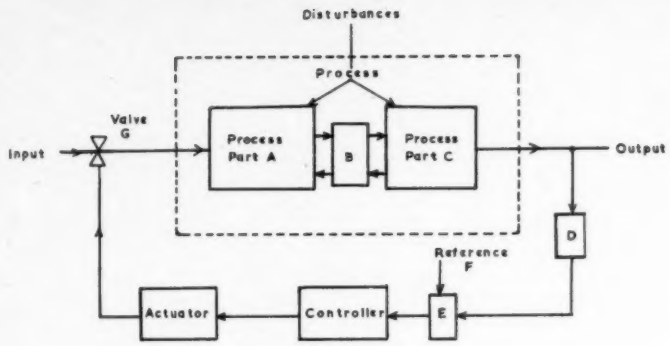


Fig. 4.

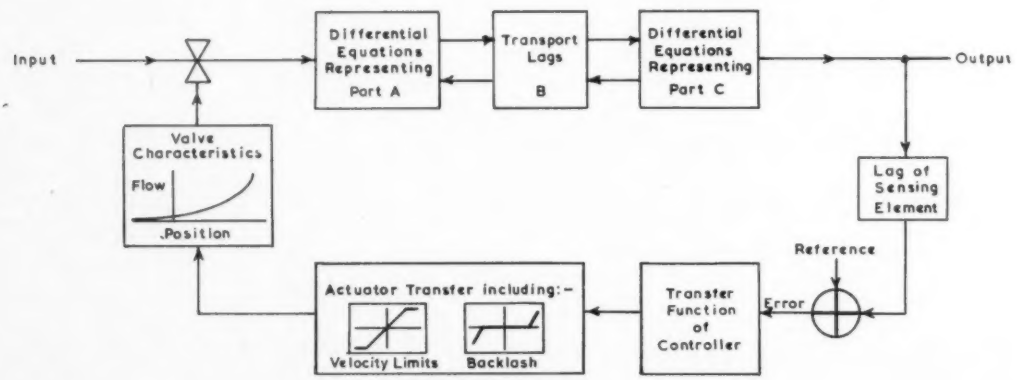


Fig. 5

the plant with the non-linear characteristics of the components of the system illustrated.

Synthesis of the processes *A* and *C* comprising two sets of differential equations and the transfer functions of the detection device and controller may be achieved using the standard methods of simulation of differential equations already described. The transport lags *B* are produced by means of the special units described in the first part of this series of articles.

The non-linearities of the actuator, which include backlash and velocity limiting, may be set up on the computer by means of special diode limit and dead-space units as shown in Fig. 6. Firstly, neglecting the effect of the diodes D1A, D1B, D2A, D2B, units 1, 2 and 3 are set up to simulate the appropriate transfer function of the actuator

$$\frac{E_o}{E_1} = \frac{1}{1 + pT_1}$$

Diodes D1A and D1B, however, are arranged to provide infinite feedback on amplifier 1 if $(E_1 - E_o)$ lies within $-e_d$ to $+e_d$; therefore for small changes of input E_1 the output E_o does not alter. If $(E_1 - E_o)$ is greater or less than $+e_d$ or $-e_d$, respectively, then diodes D1A and D1B cease to conduct and unit 1 becomes a conventional summing unit. The second set of diodes D2A, D2B, which are connected to the mid-point of the split input resistor in unit 2 and to reference voltages $+e_v$ and $-e_v$ (and therefore conduct when the input of unit 2 is greater than $+e_v$ or less than $-e_v$), provide the velocity limiting effect.

The non-linear flow/position characteristic of the valve (Fig. 7*a*) may easily be represented on the computer by a standard diode function generator which simulates curves by a series of straight-line segments (Fig. 7*b*). Suitable choice in the break points of the segments results in a very accurate approximation to the original curve.

These simulated components can now be connected together to form the complete synthesised plant. An exhaustive analysis of the system may then be carried out on the computer, in which variations of component and control characteristics may be made and their effect on the ultimate output, the plant stability and the dynamic performance determined.

These changes, which would be extremely costly or time-consuming if carried out on the plant, are easily and quickly made using the standard computer elements; for instance, the complete characteristics governing the response of a particular valve may be changed by altering the settings of a few coefficient potentiometers. Furthermore, the problem time scale may be changed and a phenomenon that may take several hours to complete can be compressed into a few minutes or seconds.

In the next article the application of a general-purpose analogue computer to a specific problem in the process control field will be described.

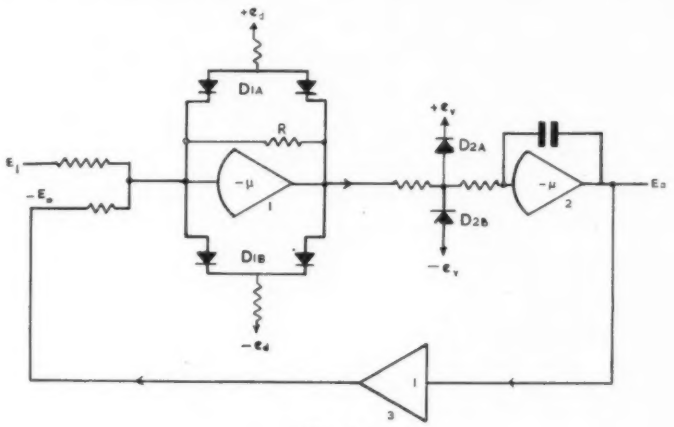


Fig. 6.

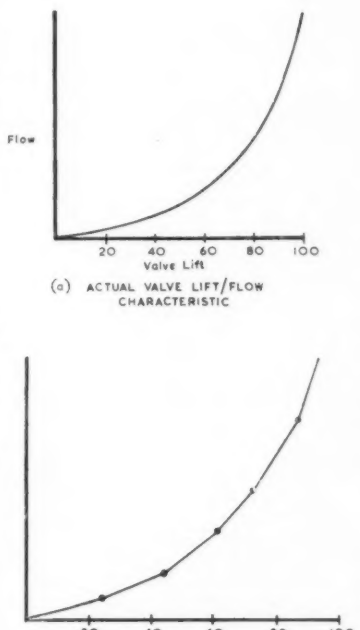


Fig. 7.

Contracts

A contract for a fully automatic heating and cooling plant to be used in the manufacture of synthetic resin has recently been awarded by V/O. Technopromimport, Moscow, to Hygrotherm Engineering, London. This is Hygrotherm's first chemical engineering project in the U.S.S.R.

The plant will consist of heat generators, circulating pumps and control equipment. An organo-silicate heat-transfer medium, *Hygrotherm* TAS-190, will be used in the plant.

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A plant costing £800,000 for the production of dyestuffs is to be built at the works of the Clayton Aniline Co. Ltd. at Clayton, Manchester. It is due to be completed and in operation by mid-1960 and forms part of a scheme to modernise the works. The plant will be engineered and constructed by Humphreys & Glasgow Ltd. to utilise processes held by Clayton Aniline.

★

The United Kingdom Atomic Energy Authority announce that contracts in connection with the advanced gas-cooled reactor project at Windscale have been placed with Whessoe Ltd. (reactor vessel), English Electric Co. Ltd. (turbo-alternator and associated equipment), International Combustion Ltd. (heat exchangers), Babcock & Wilcox Ltd. (containment building), Hick, Hargreaves (dump condenser), Mather & Platt Ltd. (feed pumps) and Whatlings Ltd. (building and civil work).

In addition, Ewbank & Partners have been retained as consultants on the turbo-alternators and that part of the steam plant within the turbine hall.

A quarterly summary of recent happenings in the United States

Americans show 'nearly unanimous' support of the country's anti-trust policies, even though the precise results of anti-trust laws are extremely difficult to measure, according to a recent survey. It is claimed that one important effect of these policies is to set up a barrier against the 'cartelising' of American industry along European lines, while without the anti-trust laws there would doubtless be more attempts to create monopolies, by merger or otherwise. A third contribution of these laws, it would seem, is to help maintain both equality of opportunity and freedom of entry in industry.

Dr. S. N. Whitney, author of the report for the Twentieth Century Fund, points out that one ironic effect of the anti-trust laws is that progress often results from attempts to outwit them. He says that while monopolies have been shown to possess grave defects—ranging from uneconomic allocation of productive resources to endangerment of free private enterprise and representative government—the *hope* of winning profits which certain kinds of monopolistic position provide is a driving force for both business firm and individual without which American economy might well stagnate.

The study finds that significant development towards greater competition in specific industries cannot always be ascribed solely to the effects of government anti-trust actions. For example, it is pointed out that in 1911 the Standard Oil and American Tobacco dissolutions laid the basis for the modern development of two important industries. The oil decision was by no means solely responsible for the growth of competition, since the westward spread of oil exploration was already creating new companies. Even in the case of tobacco, it is possible that the new type of cigarette which revolutionised the industry after 1913 might have created competition for the trust without the dissolution. It is claimed that, at the very least, however, the two decisions expanded the sphere of competition earlier than would have happened under a *laissez-faire* policy.

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A new type of nuclear power plant designed to produce radioactive isotopes and provide facilities for testing reactor fuel elements as well as generate electricity will be studied by Atomics International for the Junta de Energia Nuclear, an agency of the Spanish government. The contract calls for a study to determine the engineering and economic feasibility of a multi-purpose plant designed to generate 20,000 kw. of electricity. The plant would include a nuclear reactor moderated by deuterium oxide, or 'heavy water,' and cooled by an organic material. A reactor moderator 'slows down' neutrons produced in the nuclear fission process, helping to sustain the chain reaction. The coolant circulates through the reactor core where it absorbs heat from the fission process and transfers it to heat exchangers.

The study will include the preparation of a plant description, flowsheets, plant layouts, and estimated costs of design, construction and operation of the plant. Tecnatom, a group of private Spanish firms, will participate in the study by providing Atomics International with specifications and estimates on the turbogenerator and other facilities for the conventional or non-nuclear portion of the plant.

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The effects of radiation on the conversion of coal to methane are being studied by chemists and chemical engineers at Columbia University, New York, using as a source of radiation a 20-lb., 1,400-curie block of radioactive cobalt-60. Radiation helps to break up the coal and catalyses the hydrogenation reaction. The project is supported by a New York firm, Consolidated Natural Gas Co.

Radiation has been used to crack hydrocarbons such as gasoline experimentally and coal methanation is a related problem. The studies at Columbia have a long-term goal, however, and it might well be 20 years or more before any practicable results can come from them.

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A gleaming aluminium structure towers 200 ft. above the surrounding countryside, about 25 miles south-east of Los Angeles in Orange County, Calif., as a practical monument to chemical engineering achievement. It is used for prilling ammonium nitrate by Brea Chemicals Inc., a subsidiary of Union Oil Co.

The ammonium nitrate process at the Brea plant begins by reacting ammonia with compressed air in the presence of a platinum-rhodium catalyst. Nitric oxide produced in the reactor is cooled and further oxidised with air to form nitrogen dioxide, which is absorbed in water to form nitric acid. Nitric acid is then combined with additional anhydrous ammonia to form an 83% solution of ammonium nitrate. This solution is further concentrated by evaporation under vacuum to 95% ammonium nitrate.

To form the prills, the solution, at a temperature of about 250°F., is sprayed through nozzles at the top of the tower. Passing through the tower the ammonium nitrate droplets meet an upward draught of air and are cooled to about 175°F. They solidify into prills which, at this point, contain about 5% moisture which must be removed. Three pieces of

Link Belt equipment—a pre-drier, drier and cooler—are used in successive stages. The drying and cooling process is automatically controlled by the use of automatic temperature and air volume controls.

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Plans for the manufacture in Hong Kong of the company's range of industrial synthetic resins have been revealed by Reichhold Chemicals Inc. As a result of negotiations with prominent Hong Kong industrialists, a new company known as Reichhold Chemicals (Hong Kong) Ltd. will be established. A new plant, which will be Reichhold's 38th, is expected to be in production by the spring of 1959.

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One of the largest of international efforts for the development of a metals raw material in an underdeveloped industrial area can be seen in the setting up of a new international corporation to develop vast bauxite deposits in French Guinea (French West Africa) and to produce alumina there, as announced by Olin Mathieson Chemical Corporation. Known as F.R.I.A. Compagnie Internationale pour la Production de l'Alumine, the new corporation involves an estimated total cost of $135 million, participation by five companies from four nations, and plans to build a plant which will have an initial capacity of 480,000 tons p.a. of alumina, but is designed for possible expansion to 1,200,000 tons p.a.

The F.R.I.A. group consists of Olin Mathieson (53½% of ownership); two French companies, Pechiney Compagnie de Produits Chimiques et Electrometallurgiques and Societe d'Electrochimie, d'Electrometallurgie et des Acieries Electriques d'Ugine (26½%); Aluminium Industrie Aktiengesellschaft of Zurich, Switzerland (10%); and the British Aluminium Co. Ltd. (10%).

To Authors of Technical Articles and Books

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Leonard Hill House, Eden Street, London, N.W.1.

In addition, the Publishers and Editors of the Leonard Hill Technical Group are always ready to consider technical and scientific manuscripts with a view to publication. Correspondence should be addressed in the first instance to the Book Production Manager, at the above address.

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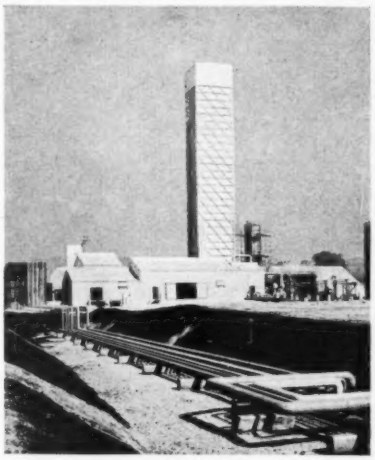
A British-born scientist, Dr. H. C. Brown, who is professor of chemistry at Purdue University and an authority on the chemistry of boron, has won the 1959 William H. Nichols Medal of the American Chemical Society's New York Section. The gold medal is conferred annually to stimulate research in chemistry.



Aluminium prilling tower at the Brea Chemicals Inc. plant in California.

Dr. Brown was co-discoverer of a method for the synthesis of boron hydride compounds, which can be modified to meet the requirements of high-energy jet fuels. They also hold promise of providing a superior propellant for rocket motors and missiles. The method devised by Dr. Brown, with Dr. H. I. Schlesinger of the University of Chicago, was first used to prepare boron compounds as part of the World War 2 atom bomb project. Since then, the materials have been developed further by Dr. Brown and their production has been vastly expanded for use in portable hydrogen generators and in the manufacture of drugs, particularly cortisone and related compounds.

A new concept of the chemistry of distorted or strained molecules is credited to Dr. Brown. He also devised a method of measuring the degree of strain in molecular structures which has become valuable in biological and pharmaceutical research.

Dr. Brown was born in London, England, in 1912.

The new $1-million metallurgical building at the Colarado School of Mines, which was opened recently at Golden, Colo., will house the entire metallurgy option taught at the mineral engineering college and will be the academic home of nearly 250 students. The majority of classes held in the new building will be upper-level courses. Under the Mines' intensified study programme only the junior and senior years are utilised for academic training in the specific option areas. During the first two years, Mines students are required to take a heavy basic knowledge study programme, including 20 semester hours of mathematics, 18 of chemistry, 10 each of physics and geology, 9 of English, 8 of civil engineering, 4 of military science and tactics and 2 of physical education. During his final two years the metallurgy student must take at least 40 semester hours in that option area.

The major laboratory, a three-storey area which utilises the north wing of the U-shaped structure, can be converted as a laboratory and/or classroom for nearly a quarter of the metallurgy courses offered. Bordering the 78 ft. × 147 ft. laboratory are a crushing mill, dispensing area, classrooms, and permanent installations for hydro, electrical and pyrometallurgy courses. An overhead crane, which runs the entire length and width of the room, is capable of lifting and transferring a 1½-ton experimental mineral-dressing pilot plant which will be stored in an area adjacent to the laboratory. An additional monorail crane will also be used for transportation of raw materials to the various laboratory areas. On the balcony are six advanced-study project laboratories.

Included in the 50,000-sq.ft. building is a 7,000-sq.ft. unfinished laboratory area. This will be placed in use as future demands increase.

Two classrooms, offices for the entire faculty, physical metallurgy laboratories and a student commons occupy the second floor. Conference and seminar rooms, smaller classrooms for drafting and mill design courses, *x*-ray defraction and spectrography laboratories, project laboratories and 16 graduate offices and laboratories occupy the third floor.

The reinforced concrete and masonry building, which is the fourth major academic building constructed on the campus since 1950, was built on the site of the former Hall of Chemistry, constructed in 1880 and razed two years ago to make way for the metallurgy building.

Company News

Keelavite Hydraulics Ltd. is the new name of the company previously known as Keelavite Rotary Pumps & Motors Ltd. The new name is more clearly indicative of the firm's activities and also signalises the amalgamation of the several companies which have hitherto represented the structure of the organisation. The announcement of the new name followed close upon an increase in the company's capital and the granting of planning permission to extend the factory.

Keelavite Rotary Pumps & Motors Ltd. was formed in 1937 to produce and market the hydraulic units developed by the original company, the Keelavite Co. Ltd., and since the war the general acceptance of oil hydraulics as a means of power transmission in every field of engineering has been reflected in the rapid expansion of the company.

The board of directors of the company now includes Mr. G. V. Keeling (chairman), Mr. H. L. Beales, Mr. M. D. Bradbury, Mr. N. B. Brookes, M.C. (see ' Personal Paragraphs '), Mr. A. Downs, Mr. A. G. Le Marchant and Mr. F. B. Levetus.

*

The oil-cracking plant at the Spondon, Derby, factory of British Celanese is to be expanded by approximately 40% of present capacity, according to an announcement from Courtaulds Ltd. The plant produces ethylene and propylene and from them a wide range of petrochemicals. Work has already begun and completion is expected in 9 to 12 months. The expansion will incorporate a very extensive use of automatic control and recording apparatus.

Chemical products other than those based on petroleum are also manufactured on the same site. These, too, are being further developed in accordance with Courtaulds' widening interest in the whole chemical field.

*

Albright & Wilson (Mfg.) Ltd. announce an agreement with Hooker Chemical Corporation, U.S.A., covering the manufacture and sale of *Hetron* resins, polyesters based on *Het* acid (chlorendic acid). Hooker Chemical hold patents covering the manufacture and use of polyesters based on *Het* acid, and Albright & Wilson (Mfg.) now have rights under these patents for the whole of Western Europe, South Africa, Australia and New Zealand, including the right to sub-license.

Price's (Bromborough) Ltd., the Merseyside oleo-chemical manufacturers, have appointed Imperial Chemical Industries (South Africa) Ltd. to represent them for the sale of their products in the Union of South Africa, Basutoland, Bechuanaland, Swaziland, Nyasaland, Northern and Southern Rhodesia, Portuguese East and West Africa and the Belgian Congo.

*

Three British engineering firms, the Power-Gas Corporation Ltd., John Thompson Ltd. and Humphreys & Glasgow Ltd., have formed a new company, Nuclear Chemical Plant Ltd., which will be concerned with the design and engineering of process and treatment plant for the nuclear industry.

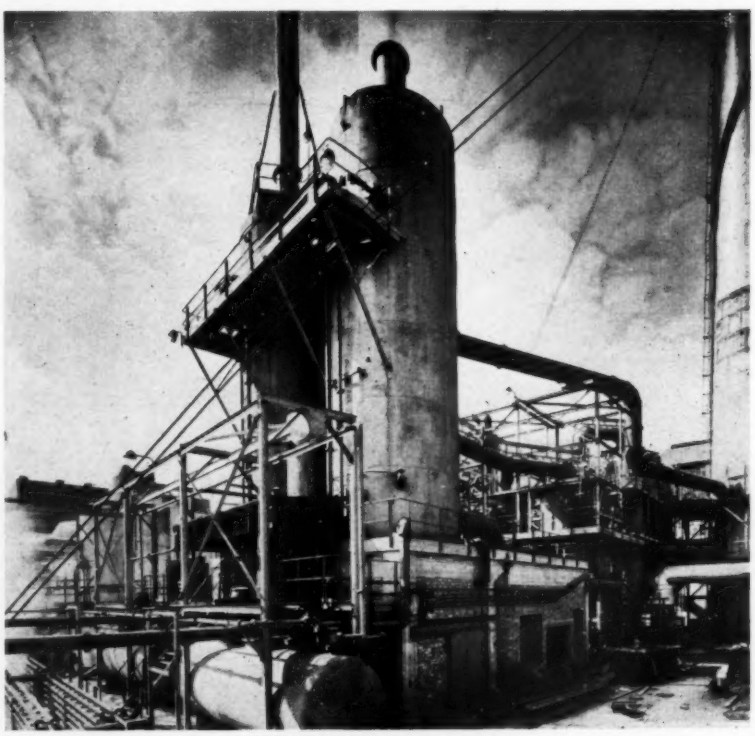
*

Production of *Wingstay* '*S*,' the first chemical to be manufactured by the Goodyear Tyre & Rubber Co. (Great Britain) Ltd., has begun at a new plant in the company's Wolverhampton factory. The new chemical is an anti-oxidant for preventing deterioration in rubber and synthetic rubber caused by oxidation or the effect of exposure. Its especial property is that it is a non-staining and non-discolouring anti-oxidant.

*

Leading companies in Great Britain specialising in rubber and ebonite industrial plant linings have formed a new product group within the Federation of British Rubber and Allied Manufacturers. The object of the group will be to collect statistics of work done in industrial installations of all kinds; to exchange and co-ordinate technical information on the application and use of natural and synthetic rubber and ebonite linings; and to promote a wider understanding among the industrial community generally of the versatility of rubber and ebonite linings.

Mr. T. H. Brooke, managing director of Redferns (Bredbury) Ltd., a member of the Federation's executive committee, has been elected chairman. Other firms at present comprising the group are: B.T.R. Industries Ltd., Dexine Rubber Co. Ltd., Dunlop Rubber Co. Ltd., Nordac Ltd. and St. Helens Cable & Rubber Co. Ltd.



SULPHURIC ACID PLANT

Another sulphuric acid plant, of 180 tons/day capacity, has successfully been brought on stream by Chemical Construction (Great Britain) Ltd. for British Titan Products Co. Ltd. at Grimsby.

INDUSTRIAL PUBLICATIONS

Variable-speed gears. Folder GP/8 is the latest addition to the current range of technical publications on Carter hydraulic infinitely variable speed gears, and is a guide to the entire range of both 'A'- and ' F '-type gears, including dimensions and rating tables. Full details of auxiliary equipment are given in separate publications, copies of which can be obtained from Carter Gears Ltd., Thornbury Road, Bradford 3, Yorkshire.

Organic chemicals. A new set of four handbooks covers the *Bisol* range of organic chemicals and, being protected with PVC covers, is suitable for use in laboratories where chemicals are handled. The four books deal, respectively, with *Bisol* solvents; plasticisers and other plastics chemicals; intermediates and miscellaneous chemicals; and methods of testing. Each contains a series of short monographs, arranged in alphabetical order, dealing with the properties, specification, main applications and handling of each product. Copies are available from The Distillers Co. Ltd., 172/3 Tottenham Court Road, London, W.1.

Coal-tar products. The West German firm, Gesellschaft für Teerverwertung mbH. of Duisburg/Meiderich, have completely reorganised their production programme, and have increased the number of products catalogued from 58 to 169, including 50 rare coal-tar constituents, not previously offered. An attractive catalogue in colour, setting out the analytical details of the various products, which are numbered for ease of reference, is available from the sterling area agents, Jacobsen Van Den Berg & Co. (U.K.) Ltd., 3/5 Crutched Friars, London, E.C.3.

Nuclear power. The purpose of a recent booklet is to highlight the importance to British industry of the development of nuclear power, to explain the structure of the nuclear-power industry as at present constituted, and to illustrate the way in which a nuclear-power station differs physically from a conventional station. Some details are also given of special lubrication problems. Copies are available free on request to Wakefield-Dick Industrial Oils Ltd., 67 Grosvenor Street, London, W.1.

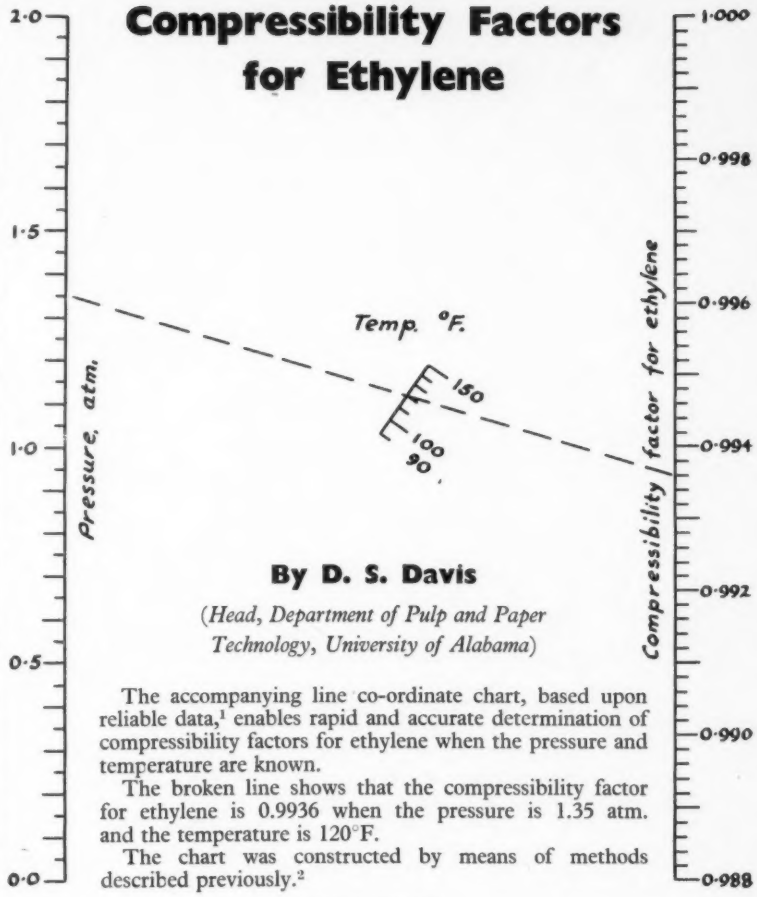
High-density polythene. The physical properties of the five types of *Rigidex* polythene, together with their recommended uses and melt index, are described in a technical information sheet. A pamphlet describing the use of *Cellobond* rubber for the reinforcement of neoprene has also been issued by the same company, British Resin Products Ltd., Devonshire House, Piccadilly, London, W.1.

Conveyor belting is the subject of a booklet which outlines and illustrates the various types and uses of natural and synthetic rubber conveyor belts available to industry, and gives information (including tabulated data) on practical features of design and maintenance which have a bearing on the welfare and life of the belt. Safe-working stresses, belt capacities, belt wear and the effects of climatic conditions are typical of the subjects discussed under this heading. The handbook is by B.T.R. Industries Ltd., Herga House, Vincent Square, London, S.W.1.

Self-priming pumps, described in a recent brochure, are available for chemical pumping duties where the pump can be mounted directly above the storage vessel; upon shut-down, delivery and suction pipes will drain naturally into the storage vessel. The plant operator can control the pump from a distant receiving end of the delivery pipe, without the necessity for priming the pump or operating valves at the suction end of the system. The brochure is by British LaBour Pump Co. Ltd., Blundell Street, London, N.7.

Nomogram:

Compressibility Factors for Ethylene



By D. S. Davis

(*Head, Department of Pulp and Paper Technology, University of Alabama*)

The accompanying line co-ordinate chart, based upon reliable data,[1] enables rapid and accurate determination of compressibility factors for ethylene when the pressure and temperature are known.

The broken line shows that the compressibility factor for ethylene is 0.9936 when the pressure is 1.35 atm. and the temperature is 120°F.

The chart was constructed by means of methods described previously.[2]

REFERENCES

[1]H. W. Pfennig and J. J. McKetta, *Pet. Ref.*, 1957, **36** (11), 309.
[2]D. S. Davis, ' Nomography and Empirical Equations,' Chap. 10. Reinhold Pub. Corp., New York, 1955.

Recent British Patents

Separating sludges

The invention relates to the removal of water from sludges, such as coal slurries, ceramic muds, paper pulp, and the like, in which the solids are finely divided. Sludge is deposited on a continuous moving belt, which is caused to vibrate at a frequency of at least 200 cycles/min., preferably 750 cycles or much more. The amplitude of vibration is from 10 to 20 mm. The vibratory movement is normally vertical but may be horizontal or a combination of vertical and horizontal. After superficial draining, the movement is stated to have the effect of continually opening and closing pores in the mass of sludge through which liquid can percolate, and of imparting differential accelerations to the solid and liquid components on account of their different densities.

By way of example, a vibrating belt, conforming to the invention, of 3 to 4 m. length, carrying a coal slurry containing 500 g. solids per litre, dewatered the slurry to a final moisture content of 9%. The belt travelled at 0.25 m./sec. and vibrated at 3,000 cycles/min.

The apparatus, illustrated by three sheets of drawings appended to the specification, is stated to be suitable also for the dry sifting or screening of solids.—800,355, *H. Halstrick* (*Germany*).

Vapour-to-solid condensation

In condensing substances from the vapour to the solid phase, difficulties arise from the build-up of very hard coatings, difficult to remove, on the cool condenser surfaces, with loss of heat transmission. If scrapers or other devices are used, they may also receive heavy deposits of built-up condensate, and the plant must periodically be shut down to clean them. The present invention consists of a condenser provided with scrapers which clean not only the cooled condenser surfaces but also the scrapers themselves. In principle, a vertical condenser shell has a horizontal cross-section in the shape of two abutting circular segments, each greater than a semicircle. Within the shell are two scrapers, rotating about vertical axes, the latter being at the centres of the two circular segments. The horizontal cross-section of the scrapers has the shape of a convex lens. The two scrapers rotate in the same direction and are spaced angularly by 90° about their respective axes. In operation, each scraper continuously scrapes the inside of its segment of the shell, and intermittently scrapes the surface of the other scraper, so that no build-up of condensate takes place on the shell or scraper surfaces. The process, illustrated by two sheets of drawings, is applicable to, for example, aluminium chloride.—800,486, *Aluminium Laboratories Ltd.* (*Canada*).

Melting of metals

The invention relates to the melting of metals, such as titanium and its alloys, which are reactive with conventional refractory materials, and also with atmospheric gases. It is known to use a titanium crucible, having an inert atmosphere, into which particles of metal are dropped and melted, more particles being dropped into the pool of molten metal. Since the material being melted and that of the crucible have the same melting point, great care must be taken to avoid excessive melting of the crucible, especially at the ' beach line,' situated at the rim where the surface of the molten pool is in contact with the crucible walls. Cooling of the crucible is necessary at the ' beach line,' especially as the heat is radiated from above.

It is now proposed to add the metallic particles to the charge at such a rate as to maintain a pile thereof above the surface of the melted metal. The addition is continued until the whole charge has been introduced, and the heating is maintained until fusion is complete. The melt is then poured from the crucible.

In example No. 1 a ' skull furnace,' shown in a drawing, was used. It had a maximum capacity of about 300 lb. of molten titanium held in a crucible of solid titanium of about 4 in. average thickness, and 2 in. beach line thickness. The furnace was heated to about 2,000°C., power consumption being 140 kw. A residual amount of molten titanium was present. Initially 50 lb. of titanium metal sponge were fed in at the rate of 600 lb./hr. Feeding continued at 200 lb./hr., maintaining a conical pile within the furnace, but not in contact with the source of heat. When 200 lb. of titanium had been added, feeding was stopped and melting continued for 30 min. During this time the optimum beach line temperature to maintain a 2-in. side wall was 1,250°C. When this had been reached, the depth of the molten metal pool was estimated, and an ingot of 187 lb. weight, with satisfactory physical properties for commercial use, was poured from the melt.—800,510, *E. I. du Pont de Nemours & Co.* (*U.S.A.*).

Improved cyclone separator

In this patent, combination of cyclone separation of suspended particles in gases with electrostatic precipitation in a single apparatus is claimed. Hitherto the cyclone and the precipitator have operated in series, since the gas velocity for the cyclone is too high for electrostatic precipitation. It has been found that conductive particles can be agglomerated, while remaining suspended, by the ionising action of an electric field, reaching a size suitable for cyclone separation. An insulated negative electrode of helical form is situated coaxially within a cyclone separator. A second electrode may be provided for effecting some measure of pre-ionisation of the gas or of the particles before entering the cyclone. There are two sheets of drawings.—800,345, *W. C. Holmes & Co. Ltd.*

Manufacture of catalysts

Pellets of catalysts such as aluminium oxide are liable to attrition in moving-bed operations and, sometimes, to damage by compression in beds of substantial depth. Existing methods of pelletising the catalysts are surveyed. It has been found that improved pellets are obtained from potentially active but non-gelatinous alumina, or the like, in a critically fine sub-division, so that the particle size is less than 40 microns. The preferred method of pulverising is by a colloid mill. The powder is then moulded by any known method from a moist dough from which most of the water used in the grinding has been evaporated. Generally the moisture content is 15 to 35%. To obtain hard, dense pellets, a high extrusion pressure is needed. Before moulding it is desirable to mix with the finely divided oxide a water-soluble compound such as aluminium nitrate, which is decomposed by heat after moulding, yielding a catalytically active oxide.

After moulding, the pellets are dried at a relatively low temperature and then heat-treated at 500 to 1,500°F. for several hours. The process is applicable to beryllia, thoria, silica, zirconia, or magnesia, as well as to alumina.—800,338, *Oxy-Catalyst, Inc.* (U.S.A.).

World News

INDIA

Blasting explosives

India's first commercial blasting explosives factory was opened recently and will have a capacity of 5,000 short tons of explosives p.a. The factory has been built by Indian Explosives Ltd., a company in which Imperial Chemical Industries Ltd., through their Indian subsidiary company, are in partnership with the Government of India. I.C.I.'s Nobel division have been responsible for the design, erection and commissioning of the plant.

Power for the factory is available from the Bokaro thermal power stations, ten miles distant, while one of the principal raw materials, liquid ammonia, is transported by rail from the fertiliser factory at Sindri, 50 miles away. Glycerine comes from soap manufacturers in Calcutta.

Nitro-glycerine is produced by the Biazzi process, using equipment fabricated in Switzerland. The factory includes plants to produce sulphuric acid, nitric acid and ammonium nitrate and, in addition, units are provided to concentrate sulphuric and nitric acids and to denitrate refuse acid from the nitration process. Other operations include cartridging and the packing of finished cartridges.

HUNGARY

Shorter hours for dangerous jobs

Shorter working hours without loss of pay have been extended in Hungary to more workers engaged on processes hazardous to health in the chemical, foundry and lead-working industries. In the chemical industry 4,600 have so far had their hours reduced. A 36-hr. week was introduced on November 1 in certain departments of the Pécs Coke Works and the United Chemical Works, while a 40-hr. week was introduced in various departments of a number of other factories, including photographic and dye works.

Workers handling lead in the manufacture of accumulators are to have their working day reduced to six or seven hours.

ISRAEL

New chemical industry possibilities

A report, compiled by the Technical Advisory Board (chairman, Sir Ben Lockspeiser of the United Kingdom) and presented to the Minister of Development in Jerusalem, recommends the establishment of a chemical combine in the district of Dimona in southern Israel, to exploit the natural resources of the Negev. Reviewing the mineral deposits of the Negev region, the Board declared that the combination of light elements and halogens, together with phosphorus and aluminium, acquires additional economic importance from their close proximity in the Negev. They form a natural complex and present the opportunity of constructing a diversified chemical industry. This would give a new look to Israel's balance of payments and would with its supporting industries contribute to the development of the whole area.

The Board was unanimously in favour of erecting a plant to manufacture elemental phosphorus by the electro-thermal process on the understanding that power would be available at a very cheap rate. The report also suggests that Israel could by-pass the stage of a pilot plant and should be able to go immediately into commercial production. However, technical and commercial know-how ought to be acquired abroad.

GREAT BRITAIN

New atomic plant decision

The Atomic Energy Authority have decided not to re-start Windscale pile No. 2. The cost of the measures which Sir Alexander Fleck's technical evaluation committee recommended should be taken before restarting pile No. 2 would be in the region of £500,000. If this cost was incurred and the pile restarted, the plutonium produced over the estimated remaining life of the pile would be extremely expensive. Plutonium is now being produced in substantial quantities from the Calder Hall reactors, and the Chapelcross reactors will come into operation over the next year.

The fuel will now be discharged and reprocessed for other uses; equipment will as far as possible be removed, and certain of the buildings will be useful for experimental purposes, saving expenditure which would otherwise have been necessary.

The conclusions of the Fleck committee, following the enquiry into the accident at Windscale in October 1957, were briefly summarised in CHEMICAL & PROCESS ENGINEERING, 1958, **39** (8), 267.

CHINA

Phosphate fertilisers

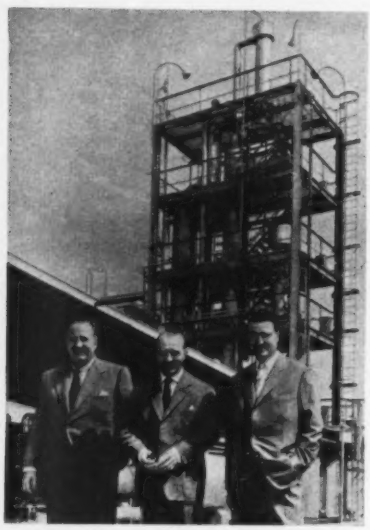
Two phosphate fertiliser plants in Nanking and Taiyuan with a total annual capacity of 600,000 tons have gone into production. The plants were designed by Chinese engineers with Soviet assistance. In Yunnan province a fertiliser plant has begun construction and will go into partial operation in 1959. It will have an annual output of 100,000 tons of synthetic ammonia, 200,000 tons of double superphosphate and 100,000 tons of fused calcium magnesium phosphate. All these projects are part of the scheme to build 66 small- and medium-scale chemical fertiliser factories and 17 large-scale factories in 1958.

The new Indian Explosives Ltd. factory at Gomia, Bihar. Part of the production area where raw materials for explosives are produced

AUSTRALIA

Sulphate of ammonia production

Investigations into the establishment of an industry to manufacture sulphate of ammonia from pyrites stockpiled at Mt. Morgan in Central Queensland are proceeding. Queensland uses large quantities of sulphate of ammonia for the sugar and fruit growing industries and experiments are being conducted for its use in connection with pasture improvement. It is claimed that sulphate of ammonia can be manufactured from Mt. Morgan pyrites at £10/ton less than that which is imported, and this is an important consideration for Queensland's agricultural industries. It is estimated that the cost of establishing a plant at Mt. Morgan for manufacturing sulphate of ammonia would be in the region of £9 million.



Touring the new Reichhold formaldehyde plant at Hamburg recently were (left to right) Mr. H. Reichhold, president of Reichhold Chemicals Inc., U.S.A.; Mr. R. Zeiss, general manager of Reichhold Chemie A.G.; and Mr. H. List, general manager, engineering and construction, of Reichhold Chemie.

Fluorine and barium chemicals

The Consolidated Zinc Corp. Ltd. is extending its plant for the production of fluorine-based refrigerant and aerosol propellants, and will also expand its production of barium chemicals for which the demand is steadily increasing.

PORTUGUESE EAST AFRICA

Oil refining plans

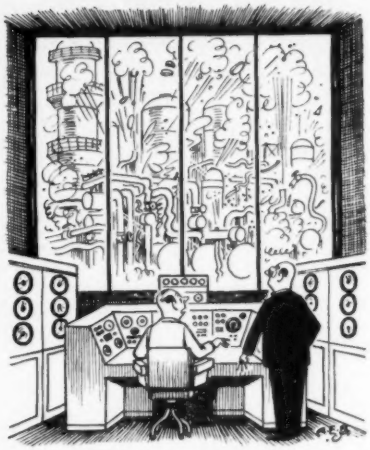
It was recently announced that the Minister for Overseas Territories in Lisbon was studying a project for the building of an oil refinery in Lourenco Marques. The instigators of this scheme are the Sociedade Nacional de Petroleos of Lisbon. The refinery would have an initial capacity for processing 200,000 tons p.a. of crude oil which would later be stepped up to 500,000 tons. It is envisaged that a capital of Contos 50,000 would have to be subscribed for this enterprise.

BELGIUM

Paints and lacquers project

A plant to manufacture Du Pont paint products will be built in Belgium. The plant will be operated by Du Pont de Nemours (Belgium) S.A., which will be formed in the near future as a subsidiary of E. I. du Pont de Nemours and Co. Inc. This will be Du Pont's first plant in Europe since the war.

Comical Engineering Corner



'What's the drill now?'

Technology Notebook

Chemical engineering at Imperial College

The Imperial College of Science and Technology, London, has issued its 1959-60 prospectus in the form of a 60-page illustrated booklet which gives full information about the College, its aims and scope, courses available, etc. The Department of Chemical Engineering, under the direction of Prof. D. M. Newitt, M.C., offers a three-year undergraduate course or a one-year postgraduate course which is open to graduates with a first degree in chemistry, physics, mathematics or engineering and leads to the D.I.C.

An important activity of the department is research in the fields of chemical engineering, chemical physics and other related branches of pure science, fuel technology, refractories, combustion, furnace technology, high-pressure technology and low-pressure technology, leading to the M.SC. and PH.D. degrees and D.I.C.

Powder metallurgy of ceramic-metal materials

A symposium on the above subject is to be held at Church House, London, S.W.1, on December 16 and 17. Further information is available from the Institute of Metals, 17 Belgrave Square, London, S.W.1.

Training for safety

Courses of interest to the chemical industry are included in the 1959 programme for the Industrial Safety Training Centre operated by the Birmingham and District Industrial Safety Group. One course is designed for supervisory grades in the chemical industry and includes a general review of accident prevention in industry with the particular hazards of the chemical industry dealt with by specialists. Another course is intended to interest junior executives concerned with plant design, materials handling, ventilation, effluent disposal and the like. There is also a one-day course for executives, personnel officers, foremen and others whose duties include the oversight of accident prevention.

Research on oil products

The new Esso research laboratories, opened recently near Abingdon, Berks., and built and equipped at a cost of some £1 million, employ over 300 technologists on research into the quality of petroleum products and research aimed at discovering new products and new methods of manufacture. This new centre is one of a chain of world-wide Esso research installations which together spent over £20 million last year on research.

The laboratories are ahead in their use of radioactive engine components as large as cylinder liners for studying the effect of lubricant quality on engine wear. Their equipment also includes apparatus for determining sulphur content by radioactivity using tritium as the source of gamma rays.

Towards analytical progress

The Society for Analytical Chemistry will receive £100 for the next three years from the Dunlop Rubber Co.

Personal Paragraphs

★ **Mr. L. H. Williams,** a member of the main board of Imperial Chemical Industries Ltd., and **Dr. John Avery,** chairman of its dyestuffs division, have been appointed directors of Ilford Ltd.

★ **Mr. R. C. Agabeg** has been appointed assistant sales manager of the chemicals division of Union Carbide Ltd. He was formerly employed with the sales development group of Monsanto Chemicals Ltd., and more recently as assistant development manager of the plastics division.

★ The National Coal Board announce the appointment of **Mr. D. Hicks** to be Carbonisation and Scientific Director of their East Midlands Division, with special responsibility for the technical aspects of coal utilisation. The appointment will be on a part-time basis and Mr. Hicks, who is at present Director of Scientific Control at National Headquarters, will continue to be responsible for the Field Investigation Group and certain aspects of research on pneumoconiosis.

★ Staff changes at the Atomic Energy Research Establishment, Harwell, announced by the United Kingdom Atomic Energy Authority, include the appointment of **Dr. J. V. Dunworth,** formerly Head of Reactor Division, as Assistant Director (Reactor Research Policy). In this post he will be special adviser to the Director of Harwell. He is succeeded as Head of Reactor Division by **Mr. T. M. Fry,** who has been a deputy Head of the Reactor Division.

★ **Dr. D. T. A. Townend,** C.B.E., director-general of the British Coal Utilisation Research Association and past president of the Institute of Fuel, recently became the first British recipient of the Gold Medal of the Institut Fraincais des Combustibles et de l'Energie, at a ceremony held in Paris.

★ Following upon the adoption of their new name (noted elsewhere in this issue), Keelavite Hydraulics Ltd. announce that **Mr. N. B. Brooks,** M.C., has recently joined their board of directors. He brings with him a wide knowledge of industry and finance, and is vice-chairman of Richard Johnson & Nephew Ltd. He was formerly chairman of the Bolsover Colliery Co. Ltd.

★ **Mr. H. P. Lord,** A.F.C., general sales manager of Sigmund Pumps Ltd., has been appointed to the board.

★ **Mr. R. A. Millar Craig** has been appointed general works manager for the new factory which is now under construction by Carbide Industries Ltd. at Maydown, Londonderry (a unit of the chemicals division of the British Oxygen Co.).

★ **Mr. H. N. Adams** has been appointed to succeed the late Mr. W. N. McCann as branch manager of Silvertown Rubber Co. Ltd. at Broughton Bridge, Blackfriars Road, Manchester 3.

Seen here at a reception held in London recently by Chemical Construction (Great Britain) Ltd. are, from left to right, Mr. J. H. Curtis, president, Chemical Construction Corp., U.S.A.; Mr. G. G. Walker, president, Electric Bond & Share Co., U.S.A.; Mr. W. Leonard Hill, chairman, Leonard Hill Ltd.; and Mr. P. D. Doulton, Matthew Hall & Co. Ltd.

Biggest-ever corrosion show planned

Britain's biggest-ever display of anti-corrosion methods and materials will be staged in London next April. It will be the 1959 Corrosion Exhibition in the Royal Horticultural Society's New Hall, Westminster, where, for four days from April 27, 69 exhibitors will show and demonstrate all that is new in the battle against corrosion.

The first Corrosion Exhibition was held in October 1957 and attracted 8,000 visitors. The organisers, the technical journal *Corrosion Technology*, have planned an even better show for 1959. Nearly 20,000 sq. ft. of floor space will be used to show a complete range of anti-corrosion products including anti-corrosion fluids, cathodic protection, cements, coatings and linings, conduits, corrosion prevention tapes, corrosion-resistant metals, derusting tools, epoxy resins, finishing processes, fuel additives, galvanising, industrial glassware, industrial porcelain, metal finishing, metal spraying, non-ferrous metals, paints, painting contractors, plastics, rubbers, valves, water treatment, wrappings and zinc products.

All enquiries about the exhibition can be answered by the Exhibition Organiser, *Corrosion Technology*, Leonard Hill House, Eden Street, London, N.W.1. Telephone Euston 5911.

Fluidised conveyor

In the article on ' Pneumatic Handling of Bulk Materials ' by W. Farnworth which appeared in our September issue, the word ' air-slide ' was used inadvertently in referring to a fluidised conveyor. Apologies are due to Fuller Co., U.S.A., who are the sole registered proprietors of the Trade Marks *Airslide* and *F. H. Airslide*, and to Constantin (Engineers) Ltd. who are the sole registered users in the U.K.

INDUSTRY REPORTS . .

Fertilisers and raw materials

The new nitrogen factory of Fisons Ltd. at Stanford-le-Hope is nearing completion and should be in operation early in the new year. The factory will produce 140,000 tons of ammonium nitrate p.a. which will be despatched in the form of a hot solution, of 86% concentration, to the company's existing fertiliser works, for the production of concentrated compound fertilisers. During the year a second sulphuric acid plant was commissioned at the Immingham factory, reported Sir Clavering Fison, chairman of the company, in his review for the year.

In his review, Sir Clavering referred to the reduction in prices for fertilisers which the company was able to make through the fall in cost of some of the raw materials, in particular phosphate rock. He pointed out that the failure of the North African phosphate rock prices to fall further has been occasioned by the existence of a monopoly selling organisation which it was hoped that the developing buyers' market in Western Europe would break down. Sulphur, too, fell in price due to competition between American and Mexican producers, and to lower freights. There was, however, a small increase in the price of sulphate of ammonia in October, 1957.

In general, supplies of raw materials appeared to be freely available, though phosphate rock from North Africa continued to give some anxiety owing to the political situation there. Furthermore, North African rock was still uncompetitive in comparison with American rock. However, Sir Clavering said, new sources of supply will be available in Africa within a few years and there will also be available increased supplies from the U.S.A., and perhaps from Russia, which should ensure that requirements are met.

There was a rise of £2,158,000 in 1958 in the net amount of fixed assets of the Group.

More gas from oil

The amount of gas made from oil in Britain is still increasing, as is revealed in statistics just issued by the Gas Council for April, May and June, 1958. Gas production was nearly 1% higher than during the same period of the previous year, coal-gas manufacture being reduced by 5% but water-gas made being 35% higher. Oil-gas production increased from just over 1.8 million therms in April-June 1957 to 7.1 million therms in April-June 1958.

New gas-making plant of 30 million cu. ft. daily capacity was brought into use during the first quarter of 1958/59. This compares with 12.9 million cu. ft. in the first quarter of 1957/58.

Bright prospects for nickel

It is estimated that in 1958 the grades of stainless steel that contain nickel will be found to account for a greater percentage of the total stainless steel output than in any other year during the last decade, according to the chairman of the International Nickel Co. of Canada Ltd., Dr. J. F. Thompson, reviewing the first nine months of 1958. Dr. Thompson said stainless steels represent the largest single market for nickel and it is a market that does not depend to a major extent on any particular application. Uses are so diversified that the requirements for nickel in stainless steel will increase without being unduly sensitive to trends in particular applications or industries.

The Leonard Hill Technical Group—December

Articles appearing in some of our associate journals this month include:

Manufacturing Chemist—Grinding and Grinding Machinery; Veterinary Antibiotic Preparations; Recent Developments in Gas Chromatography, 2; Olfaction, A Comparison of Homogeneous and Heterogeneous Adaptations.

Atomic World—Construction Work on the Berkley Nuclear Power Station; Selecting Nuclear Power Station Sites; Special Density Concrete for Shielding; High Vacuum for Nuclear Industry; Nuclear Energy in Sweden.

Automation Progress—Inspection after Machining; A New Automatic Sizing System; Automatic Gauging; Remote Control in the Soviet Gas Industry; Instrumentation and Control of Ice-cream Manufacture; Control Without Mathematics.

Paint Manufacture—Resin Manufacture by Induction Heating; Epoxide Resins *versus* Corrosion; I.C.I. Marine Research Laboratories at Brixham; Testing Marine Paints.

Food Manufacture—Mechanisation in the Cheese Industry; Measurement of the Colour of Evaporated Milk; Mushrooms by the Million; The Bacterial Population of Fresh, Healthy Cucumbers.

Corrosion Technology — Determining the Corrosion Aggressiveness of the Atmosphere; Corrosion Problems with Pressure Vessels; Rubber and Ebonite-lined Storage Tanks.

A.B.C.M. Council for 1958-59

The Council of the Association of British Chemical Manufacturers for 1958-59 will include: *president*, Sir Walter Worboys (I.C.I. Ltd.); *vice-presidents*, Dr. F. H. Carr, C.B.E.; Sir Roger Duncalfe; Dr. E. V. Evans, O.B.E.; Sir Graham Hayman (Distillers Co. Ltd.); Sir Harry Jephcott (Glaxo Laboratories Ltd.); Mr. C. F. Merriam, M.C.; Mr. L. P. O'Brien (Laporte Chemicals Ltd.); and Mr. G. F. Williams (British Drug Houses Ltd.).

Elected members include: *chairman*, Mr. B. Hickson (Hickson & Welch Ltd.); *vice-chairman*, Sir William Garrett, M.B.E. (Monsanto Chemicals Ltd.); and *hon. treasurer*, Mr. J. L. Harvey, M.B.E., D.L. (Fullers' Earth Union Ltd.).

MEETINGS

Institution of Chemical Engineers

December 10. 'Chemical Engineering as Applied to the Manufacture of Antibiotics,' by J. Stuart, 6.30 p.m., College of Technology, Birmingham.

December 17. 'Liquid Distribution in Grid Packings,' by J. W. Mullin, 5.30 p.m., Geological Society, Burlington House, London, W.1.

January 6. 'Feed Water and Boiler Water Standards in the Central Electricity Generating Board,' by R. Ll. Rees and F. J. R. Taylor; 'The treatment of Water for an Industrial High-Pressure Industrial Boiler Plant,' by J. Arthurs, J. A. Robins and T. B. Whitefoot; 5.30 p.m., Geological Society.

Society of Chemical Industry

Chemical Engineering Group

December 9. 'Some Aspects of Radiation-Induced Chemical Processes,' by Dr. R. Roberts, 6 p.m., Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

Chemical Society

December 12. 'Silicones: An Introduction to their Chemistry and Applications,' by Dr. G. G. Freeman, 7.45 p.m., Marischal College, Aberdeen. Joint meeting with the Royal Institute of Chemistry and the Society of Chemical Industry.

Society of Instrument Technology

December 12. '*p*H Measurement and Control,' by J. W. Broadbent, 7 p.m., Regent House, St. Phillip's Place, Colmore Row, Birmingham 3.

Incorporated Plant Engineers

December 11. 'Atmospheric Pollution,' by B. Richardson, 7 p.m., Roadway House, Oxford Street, Newcastle-upon-Tyne.

December 17. 'Treatment of Trade Effluents and Methods of Purification,' by T. Waldmeyer, 7 p.m., Kings Head Hotel, High Street, Rochester, Kent.

Institution of the Rubber Industry

December 12. 'Some Radiation Effects on Rubber,' by E. E. Gunn, 7.30 p.m., Bell Hotel, Leicester.

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WHAT'S NEWS about

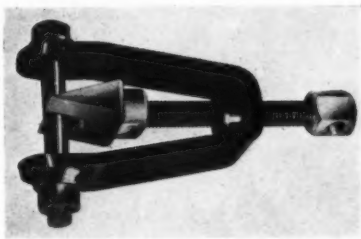
★ Plant
★ Equipment
★ Materials
★ Processes

This illustrated report on recent developments is associated with a reader service that is operated free of charge by our Enquiry Bureau. Each item appearing in these pages has a reference number appended to it; to obtain more information, fill in the top postcard attached, giving the appropriate reference number(s), and post the card (no stamp required in the United Kingdom).

Flange spreader

Quick and safe opening of bolted pipe flanges, without causing damage to the faces of the flanges, can be achieved by the use of a flange spreader announced by the Borer Engineering Co. Other advantages claimed are that there is no danger of explosion or fire due to sparks, flanges can be safely held apart at a required distance to enable workmen to clean or prepare the joint, and that the device can be used in small confined spaces.

It is used by removing the bolts, inserting the pin of the spreader in a bolt hole, and inserting the wedge between the flanges by tightening the drive screw. Prototypes tested on oil pipelines were used in pairs mounted diametrically.

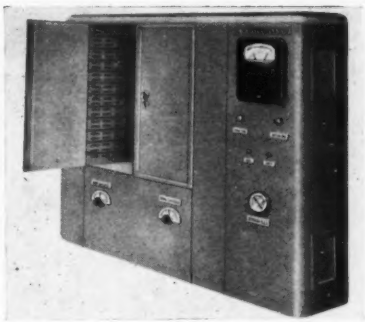


Bolted-pipe flange opener.

Fabricated from mild steel with nickel chrome steel driving screw, wedges from tool steel, hardened and tempered, the spreaders can be made to suit all sizes of pipes. **CPE 1068**

Hot air drying cabinet

A pilot-scale drying cabinet has been designed by L. A. Mitchell Ltd. to meet the need for a flexible processing unit for drying and preheating powdered and granular materials. The unit is standardised on a loading capacity of 10 drying trays, size 32 in. by 16 in. and $1\frac{1}{4}$ in. deep. All the trays are arranged at a convenient working height and the bottom tray is positioned at approximately 20 in. from floor level. New features include extruded door seals, eliminating air leakage at this point. Special car-type door handles are designed to give positive closure and pleasing appearance.



Cabinet for drying and preheating powdered and granular materials.

The unit is provided with a variable air-velocity control, extending between definite limits, and the velocity can be adjusted through a single knob control mounted on the front of the cabinet. Air inlet and outlet vents are fitted with very fine adjustment, giving maximum control over the quantity of air introduced and rejected from the unit during processing. All these controls are provided with positive stop settings and clearly engraved scales to permit reproduction of previously determined test conditions.

This model has completely automatic temperature control up to 200°C. on the electrical type and according to steam pressure on the steam-heated type. The instruments can be calibrated to suit particular requirements. **CPE 1069**

Pressure regulator

A pilot-controlled air pressure regulator model 20AA, made by Shipston Engineering Co. Ltd. for their associates, C. A. Norgren Ltd., is claimed to have greater capacity with closer control of pressures in the $\frac{3}{4}$ to 1-in. pipe size than many other types. It offers extreme precision over a wide operating range, from 2 to 120 p.s.i. It delivers more than 200 cu.ft./min., and utilises air pressure for control of delivered air. **CPE 1070**

PVC tubing

Flexible and rigid PVC tubing and sleeving, known as *Telecovin*, is being produced by the Telegraph Construction & Maintenance Co. Ltd. It is made in black or white, in colours, or in transparent form for the observation of flow. There is a standard type and a type made from a PVC compound suitable for use in contact with drinking water, milk, beer, etc.

The tubing is claimed to have excellent chemical resistance and can be used for the conveyance of inorganic chemicals in solution. Tubing is made, in the main, to specification, with an upper limit of $\frac{3}{4}$ in. bore. **CPE 1071**

Flowmeter

A new design of indicating *Flowrator*, model 2700, eliminates the use of stuffing boxes and packing glands by the use of rubber 'O' rings which seal the tube ends to the metal end fittings incorporated in the metal body. This body is an assembly of mild-steel pressings obviating the need for bolts

and screws. Advantages claimed for this new instrument include:

(1) The metering tube is completely isolated from pipeline stresses.

(2) Metering tubes can be snapped in without the use of tools and without disconnecting or disassembling the meter.

(3) Range changing and cleaning are reduced to simple quick routines which may be accomplished without removing the instrument from the line.

(4) The meter withstands high pressures.

(5) The meter is inherently simple in design and the necessity for maintenance is reduced to an absolute minimum.

Different in appearance from the model 100 *Flowrator* by the same makers (Fischer & Porter), the model 2700 retains all the features of the earlier model, including wide-angle toughened-glass viewing windows, fitted front and rear; fully rotatable end fittings; reproducible metering tubes and floats giving a predictable calibration performance. **CPE 1072**

Flow quantity measurement

A new accessory, introduced by a British company, is a flowmeter which measures the actual quantity of liquid being pumped, and not the rate of flow. The flowmeter is available in two sizes, 3½ in. or 5 in. diam.

Constructed of die-cast alloy, it will withstand normal industrial usage, and also contains a built-in easily cleaned filter and non-return valve. It has been designed for use with thin mineral oils or liquids of a similar nature, and a modified unit suitable for use with solvents will be available shortly.

A similar unit is suitable for use with heavy oils, water, acids, foodstuffs, etc. Makers are the British Central Electrical Co. Ltd. **CPE 1073**

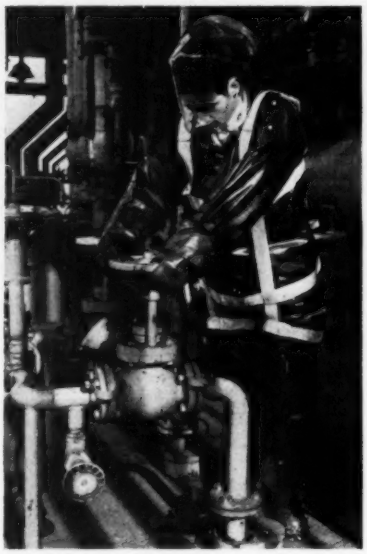
Improved arc-welding equipment

The *Autopak* automatic arc welding equipment introduced by Rockweld Ltd. has now been modified and improved, enabling its uses to be considerably extended. The main addition is a boom-mounting for the self-propelled carriage. This boom is 20 ft. long, and can be mounted at varying heights on a wheeled 'A' frame.

The unit, it is claimed, will make butt, fillet and lap welds up to 17 ft. 6 in. long at any desired height above floor level. It can be used as a manual welder, and at the same time can be extended to any fully automatic operation. **CPE 1074**

Chromatographic instrument

A new chromatographic refractometer which should reduce research time by 75% has been manufactured by the Phoenix Precision Instrument Co., U.S.A. Once the test is started, the analysis continues unattended. Operation is possible by inexperienced personnel, and a range-extension system allows setting the scale indicator without changing cells, without upsetting zero, and with no sensitivity loss. Only one dial adjustment is necessary. This null type instrument is designed for continuous working at 115 volts 60 c/s a.c. **CPE 1075**



SAFETY SUIT

Shown here is the R.F.D. Opal *suit, Mark I, developed by the industrial safety division of R.F.D. Co. Ltd., in co-operation with the chemical industry. The suit seals off its wearer from toxic fumes, vapours and dust, the wearer receiving a supply of cool fresh air to all parts of his body through an external pipeline. The air supply is regulated by the wearer, air entering the suit at waist level and being exhausted through non-return valves in the arms and legs of the suit. The suit is made from a strong, lightweight PVC-coated* Terylene *fabric, with the hood in transparent PVC sheeting to allow* 360° *vision, and the hands and feet of the suit are sealed off with PVC, over which suitable gloves and boots can be worn. The suit is available with or without an integral* Terylene *webbing lifting harness, which allows an unconscious operator to be lifted vertically to safety.* **CPE 1076**

IMMERSION HEATING OF ACIDS

A safe and economical method of heating acidic liquids is offered by *Vitreosil* electric immersion heaters, now available in a demountable model with rubber or PVC cap. The envelope of pure fused silica is claimed to be completely unaffected by all acids, except hydrofluoric and phosphoric, even up to the highest temperatures.

By designing a two-piece moulded cap, it has been possible to simplify the servicing of these heaters. When used for continuous processing, replacements can be made in a few minutes.

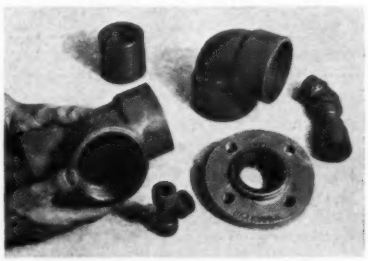
The unit consists essentially of an inner cylindrical component carrying the heating element connected to a cable through the cap. This inner component rests on a pad of asbestos at the bottom of the containing sheath. The moulded rubber or PVC cap and the electric cable are firmly bonded together and no damage can be caused by sharp bending of the cable. An internal earth wire is incorporated in every unit and the incorporation of an earth leakage circuit breaker ensures maximum safety.

The new demountable top applies to all the standard heaters; heaters of other shapes are available to suit special requirements —for instance, flat-loop heaters with vertical arms. Single-phase heaters can be star connected externally to operate from three-phase supplies. Makers are the Thermal Syndicate Ltd.

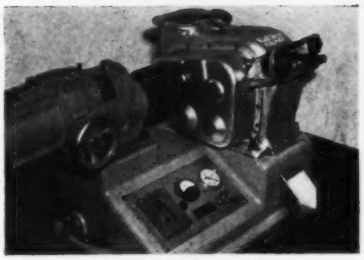
CPE 1077

High-impact PVC piping

High-impact PVC piping is being manufactured by Extrudex Ltd. in diameters from ½ to 12 in. The piping, made with *Geon* RA 170, supplied by



Moulded high-impact PVC fittings.



COMPRESSING BULK MATERIALS

This machine, the purpose of which is to increase the bulk density of materials, chiefly powders, and so save on packaging and storage, comes from Western Germany and is introduced to the U.K. by Peter Millbrook Ltd. As an example of its use, Aerosil *is said to increase in density from between* 15 *and* 30 *to* 120 *g./cu.dm. Another example given is yellow iron oxide, the increase being from* 150 *to* 400 *g./cu.dm. Savings result in packaging and storage. The machine is continuous in operation, and is generally installed before packing machines. Two sizes are available, according to the duty required.*

CPE 1078

British Geon Ltd., is non-corrodible, can withstand heavy blows and is one-fifth the weight of steel pipe. It is self-coloured and needs no painting.

A new range of pipe fittings in the same material makes possible the construction of complicated pipeline systems entirely in high-impact PVC.

CPE 1079

Oil diffusion pump

A high-speed, 3-in. diffusion pump has been developed for use in laboratory and small industrial vacuum applications.

The pump body is a water-jacketed cylinder of non-corrodible copper alloy, enclosing an aluminium three-stage jet system, while a readily detachable heating unit, comprising a metal-sheathed radiant element, lagged in a polished aluminium cover, is fitted to the base of the pump.

Metropolitan-Vickers Electrical Co. are the makers. **CPE 1080**

Steam and hot-water boilers

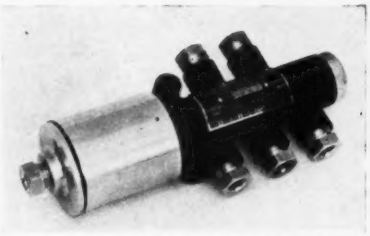
A new range of Economic boilers has been developed by Frederick Kay (Engineering) Ltd. Complete with medium-pressure-air heavy oil burners, together with usual mountings and automatic controls, two-pass and three-pass units are available in sizes from 1 million to 10 million B.Th.U./hr. **CPE 1081**

Cylinder-operated valves

A new range of cylinder-operated valves is designed to ensure positive movement of the valve member under extremes of operating conditions. Single- or double-cylinder-operated valves for two-way, three-way or four-way operation are available in $\frac{5}{16}$ and $\frac{1}{2}$-in. sizes. A feature of these valves is the large piston area provided by the cylinder, giving a greater thrust to the valve sliding member—a safeguard against out-of-sequence operation resulting from, for example, adverse weather conditions.

As an example of the successful application of cylinder-operated valves, Maxam Power Ltd. cite the case of an installation handling china clay slurry in an exposed moorland area where, in winter months, early-morning temperatures are often well below freezing point and there is a tendency for control equipment to operate sluggishly, particularly after the plant has been idle overnight. A *Maxam* 4-in. bore, double-acting air cylinder is now used to operate tee-port valves in the 6-in. pipeline. The controlling valve situated immediately below the cylinder is one of the new *Maxam* range and is cylinder-operated in both directions.

CPE 1082



Four-way cylinder-operated valve.

Stoneware fume cupboard

Produced in Germany and available through Anderman & Co. Ltd., London, the *Godei* acid-proof, white-glazed stoneware fume cupboard offers a safe means of handling chemicals in analysis and similar work.

Features of these units, according to the makers, are (*a*) the attainment of pure air in laboratories and workshops owing to practically perfect absorption of gases and fumes; (*b*) easy installation and connection, even if no de-airing piping is available; (*c*) removal of gases and fumes by means of a plastic exhaust fan; (*d*) easy cleaning of the plain and glazed equipment which is also acid-proof and impermeable, fitted with porcelain reaction bowls or glasses on corrosion-proof porcelain supports; and (*e*) no splashing of acid outside during the work, since the hood is perfectly closed and overflowing chemicals are collected in the drawer. **CPE 1083**

Cyclopentanone

Cyclopentanone has been produced on a commercial scale by Price's (Bromborough) Ltd. It is a versatile starting material of potential interest for a wide variety of applications, particularly in the field of synthetic perfumery and flavouring materials. It is claimed to have uses as an insecticide, as a shrinking agent for stretched cellulose acetate rayon, in wool dyes, to be interchangeable with acetone and cyclohexanone in a very large number of condensation reactions and to have special solvent properties for several types of polymer, particularly PVC.

Cyclopentanone is available in aluminium containers of from 1 to 420 lb. capacity. **CPE 1084**

Rotary driers

Removal of free moisture from bulk materials is achieved by thermal methods in the Ruggles-Coles rotary driers, of which there are seven distinct types catering for the varying methods needed to achieve dryness without chemical change. Direct, indirect and direct-indirect heating methods are employed. The shells are of welded or riveted plate in mild, firebox or copper-bearing steels, aluminium, *Monel*, nickel or stainless clad steels. Two tyres are rigidly attached to the shell.

All the driers are driven by spur gearing and have either gravity feed or screw feed arrangements, depending on the material to be handled. The driers are generally equipped with exhaust fans. Furnaces can be fired by coal, wood, oil, or gas, and automatic temperature recording and control systems are optional.

Internal arrangements vary considerably according to model and the method of heating. One model, the XA, consists of two concentric cylinders with the discharge end set lower than the feed end. The hot gases from the furnace pass down the inner tube and return between the inner and outer shells.

Further information can be obtained from Head Wrightson Stockton Forge Ltd. or by using the reply-paid card.

CPE 1085

Package level unit

For level measurement involving a purge system the *Electroflo* level package unit interconnects the standard purge pneumerstat, miniature transmitter and air set into a small panel, the gland plate of which terminates in three connections for air supply, input from dip tube and level signal output.

For quickly fluctuating levels where remote and continuous measurement is required, the system incorporates a locally mounted transmitter having a boosted output. It may be adapted to automatic control by using standard air-operated controllers. The package unit design reduces the installation of piping on the site. **CPE 1086**

One-piece polythene moulding

The latest addition to the *Black Knight* range of plastic products, proprietors Tool Treatments (Chemicals) Ltd., is a 13-gal. polythene container with fitted all-plastic tap. The body is specially reinforced and threaded so that the tap can be screwed in to give a perfect, liquid-tight fitting.

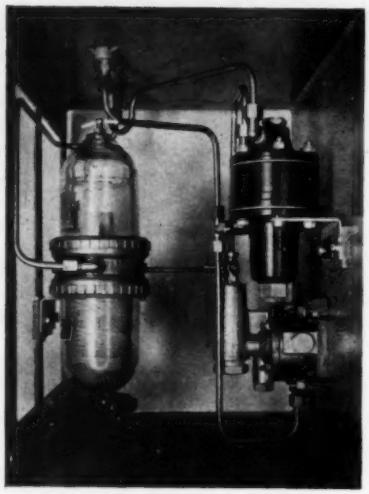
Another feature is the screw-cap lid which is claimed to give perfect sealing, while there is also an anti-splash rebate inside the lid making the container the safest method of storing the transporting corrosive liquids. **CPE 1087**

Distillation unit for inflammable solvents

Almost negligible running costs are claimed to be a feature of a new distillation unit for connection to any steamline, saturated or superheated, and feeding the exhaust steam back to a heating system, washing plant or auxiliary machine. The unit comprises a well-insulated distilling chamber of 44 gal. capacity with a water-cooled condenser, and can be fitted with either a manual or automatic temperature regulator.

The unit is claimed to be simple and safe to operate when used for the removal of oils, greases, pigments and other dissolved impurities from white spirits and solvents such as turpentine wash kerosene, nitrosolvents, trichlorethylene, etc. All solvents with a boiling point under 140°C. can be distilled by the use of saturated steam at 45 p.s.i.g. Liquids with a boiling point higher than 140° require superheated steam.

The standard unit is also available fitted with electrical heating elements and automatic temperature control. A smaller model is electrically heated and has a capacity of 6½ gal. Suitable for liquids having a boiling point ranging from 40 to 200°C., it incorporates a three-stage heating element and a thermostat which controls the heat and automatically switches off the supply when the spirit has been distilled. Liquid Systems Ltd. are the suppliers. **CPE 1088**



Level measurement unit.

IN CASE YOU MISSED THEM . . .

Items described in previous issues this year are listed on pages 463 and 464. Use the reply-paid card to obtain further details.

Easy-to-use chemical-resistant paints

Ease of application is a feature claimed for a new range of chlorinated rubber paints, *Avigel* 250, which are stated to be no more trouble to use than oil paints but give full chemical and water resistance. Makers are Corrosion Ltd. **CPE 1089**

Heavy-duty valves

Martonair Ltd. have introduced a new series of pneumatic control valves which are claimed to be suitable for heavy duty in all industries and are made in both three-port and five-port form, in ½, ¾ and 1-in. B.S.P. sizes. **CPE 1090**

Ceramic-to-metal seals

Originally developed to overcome the limits imposed upon radio valve performance by the use of conventional glass-to-metal seals, Ferranti ceramic-to-metal seals can now be used in the chemical and atomic energy industries as terminals for vacuum and pressure vessels operating at elevated and sub-normal temperatures.

This development stemmed from the requirements of the atomic energy industry for a considerable increase in the standard of reliability of seals for use as terminals in equipment such as atomic particle detectors, etc. Ceramic-to-metal seals were found to provide a solution to this problem. Alumina-type ceramics are well suited to vacuum and pressure-vessel applications on the grounds of mechanical strength, low thermal shock and high melting point. **CPE 1091**

Graphite block heat exchanger

Another model, having a heat exchange area of 300 sq. ft., has been added to the range of long-tube graphite heat exchangers introduced last year by Powell Duffryn Carbon Products Ltd.

There are now 30 standard models in the range covering heat-exchange areas of from 4 to 300 sq. ft. and special constructions in graphite are undertaken by the company for specific applications. **CPE 1092**

Atomisation

Spray nozzles of a variety of types are offered by Ascog Ltd. for the atomisation of water or other fluids. There is, for example, the *Lechler* eccentric sprayer which, simply constructed and involving no moving parts or insets, will not clog even when the sprayed liquid contains substantial particles. Another type, the spiral sprayer, can be connected to any fluid pipe working under pressure and can be used for steam and gas cooling, spray drying, etc. The multiple sprayer contains a series of nozzles with removable cores to which the liquid to be atomised is fed through a common connection piece, and this type is available in various designs to give acute or obtuse angle spray, fine or coarse atomisation.

Numerous other types are available, all, with the exception of compressed-air nozzles, working under liquid pressure. **CPE 1093**

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